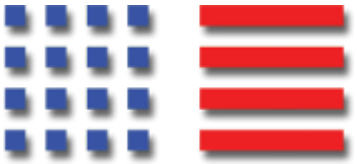

VXD Test Beam

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[a]University of Bonn
[b]KEK

VXD Consortium

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DESY TB Schedule 2016

	Week		TB21		TB22		TB24/1		TB24
			DATURA	none	DURANTA	none	Telescope in PCMAG	PCMAG	none
4-Jan-16	1		Shutdown						
11-Jan-16	2								
18-Jan-16	3								
25-Jan-16	4								
1-Feb-16	5								
8-Feb-16	6								
15-Feb-16	7								
22-Feb-16	8								
29-Feb-16	9								
7-Mar-16	10		Startup		Startup		Startup		Startup
14-Mar-16	11		CMS-Pixel-Phase1		Mu3e				
21-Mar-16	12		Goettingen-CMOS		ATLAS-Pixel-AMSH35				
28-Mar-16	13		ATLAS-Pixel-MPP						
4-Apr-16	14		CMS-Pixel-Phase1				Installation Belle-II		
11-Apr-16	15		PLUME						
18-Apr-16	16		PLUME						
25-Apr-16	17		ATLAS-Pixel-AMSH35						
2-May-16	18		CMS-Pixel-PII-KA			CALICE-AHCAL			SiPM
9-May-16	19		CMS-Pixel-PII-KA						SiPM
16-May-16	20								
23-May-16	21		ATLAS-Strip-Glue		ATLAS-ITK-Strip			LCTPC-FLC	
30-May-16	22		ATLAS-Strip-Glue		ATLAS-ITK-Strip			LCTPC-FLC	
6-Jun-16	23								CMS-Pixel-Phase1
13-Jun-16	24								
20-Jun-16	25					CALICE-AHCAL			
27-Jun-16	26								
4-Jul-16	27								
11-Jul-16	28								
18-Jul-16	29								

TB24 and TB24/1
CW 14 – CW 17

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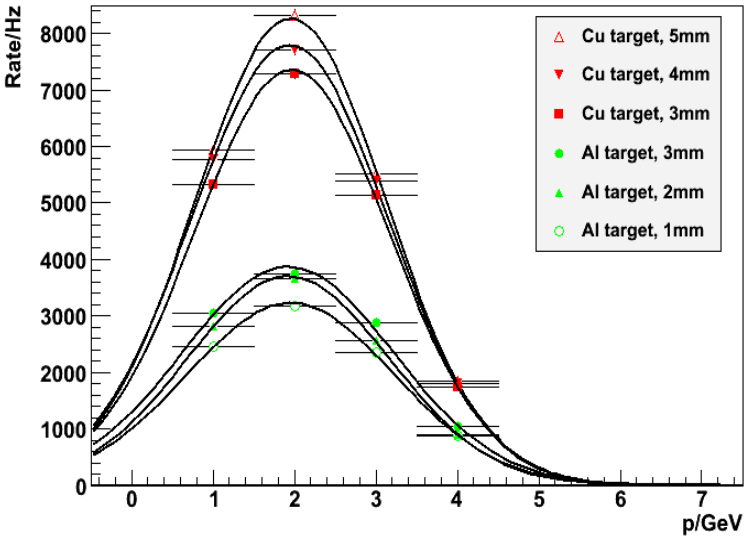
DESY TB

- VXD common test beam in April 2016 (4 weeks)
- Small sector of the final sensors and ASICs*
  2 PXD + 4 SVD layers
- Complete VXD readout chain: HLT, monitoring, event building, PocketDAQ
- CO_2 cooling, slow control, environmental sensors
- Illumination with (up to) 6 GeV e^- under solenoid magnetic field (PCMAG)
- Alignment, tracking algorithms, ROI



- **Goal**: **System integration and Phase 2 Commissioning**

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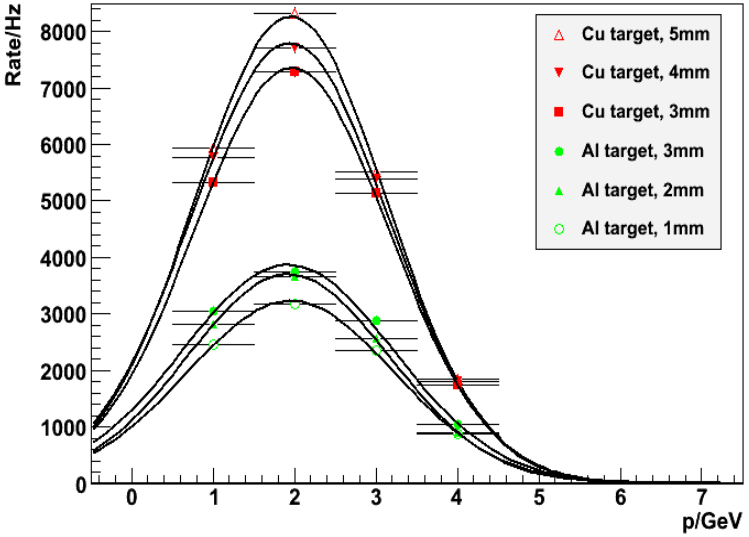
DESY TB

- Operation with beam between Apr-19 and Apr-29
- Electron energies between 2 GeV and 5 GeV
- Trigger rate between ~0.5 kHz and ~3 kHz
- Different solenoid settings (B = 0 T, 0.2 T, 0.4 T, 0.5 T, 1 T)

https://belle2.cc.kek.jp/~twiki/bin/view/Detector/SVD/DesyBeamTest2016

https://www-h1.desy.de/belle2elog/



- **<u>Goal</u>: System integration and Phase 2 Commissioning**

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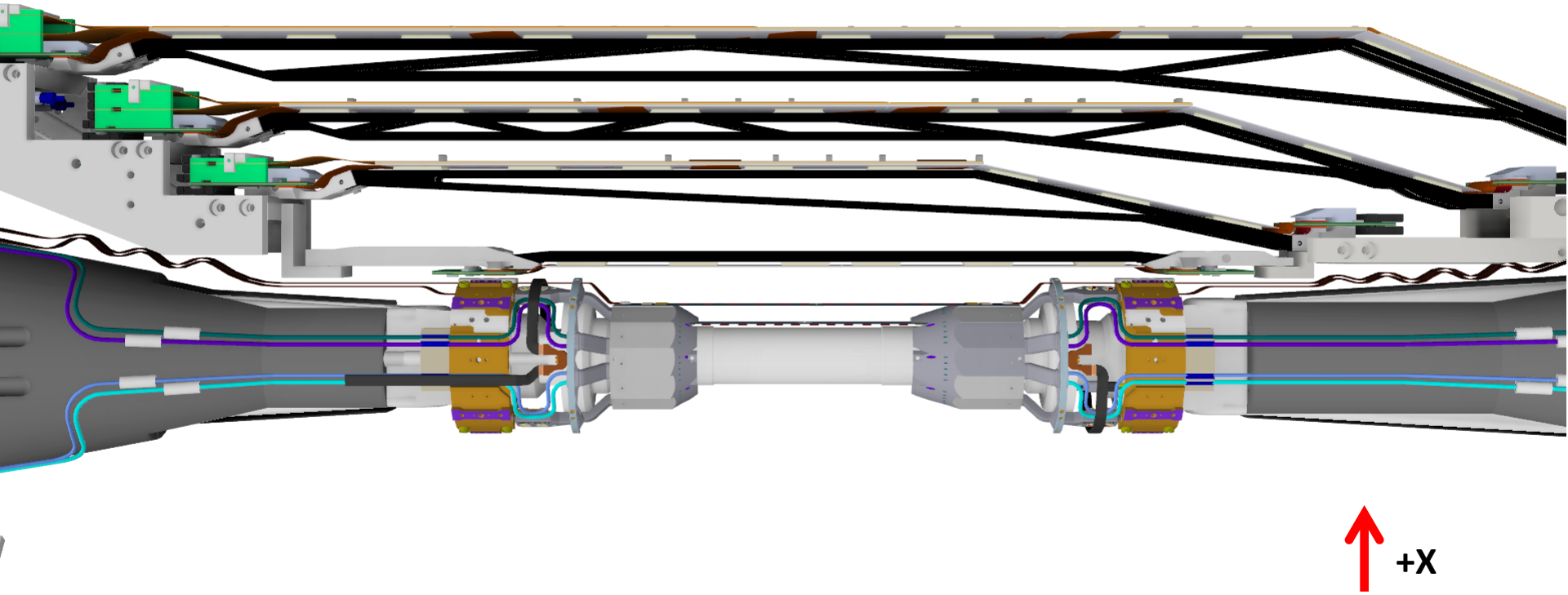
VXD Phase 2 Hardware

- Two PXD and four SVD layers
- +X direction, horizontal plane (highest background sensitivity)

Test Beam set up to mimic Phase 2 arrangement



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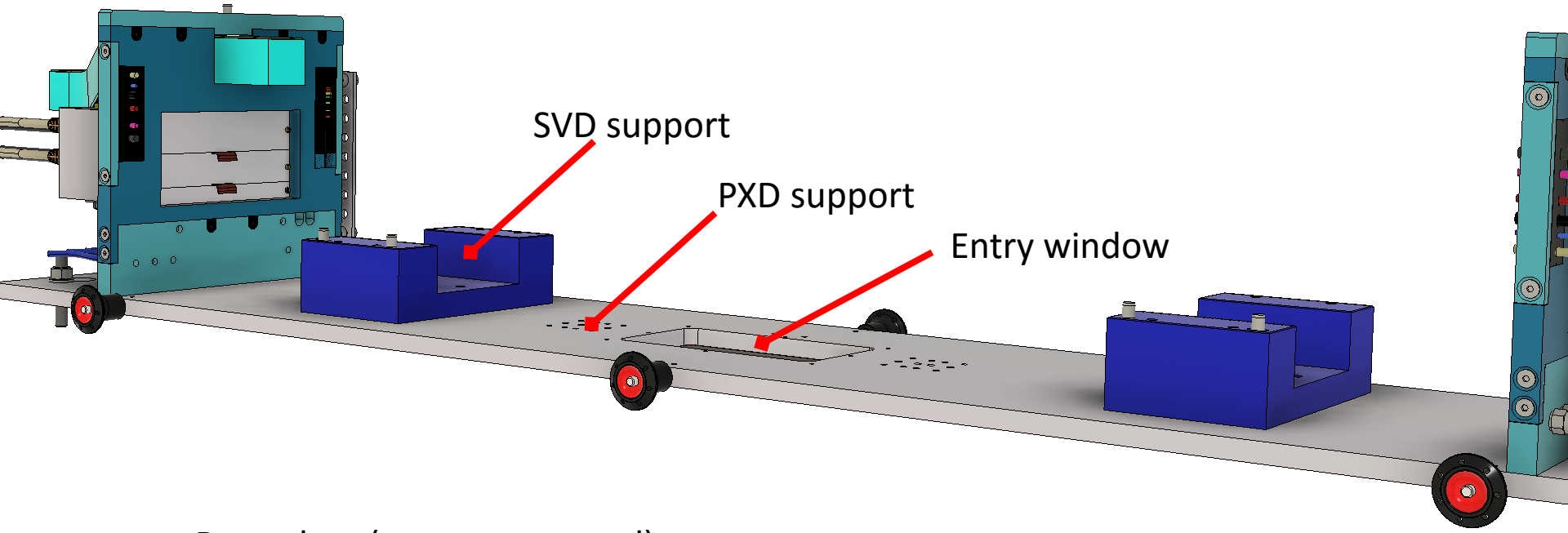
Test Beam Set Up



Base plate (common ground)

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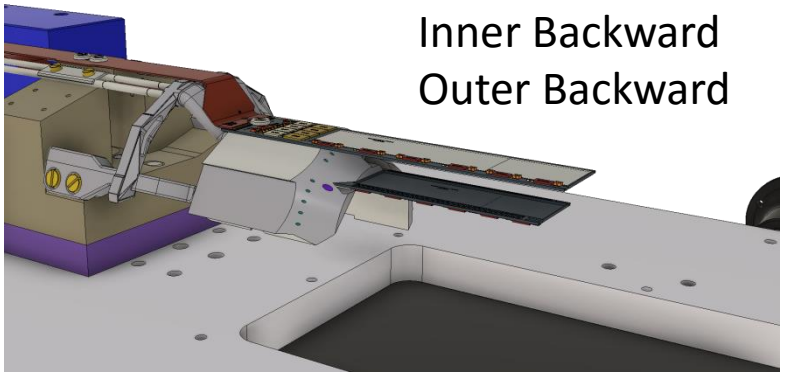
Test Beam Set Up



Inner Backward
Outer Backward

Preassembled PXD*

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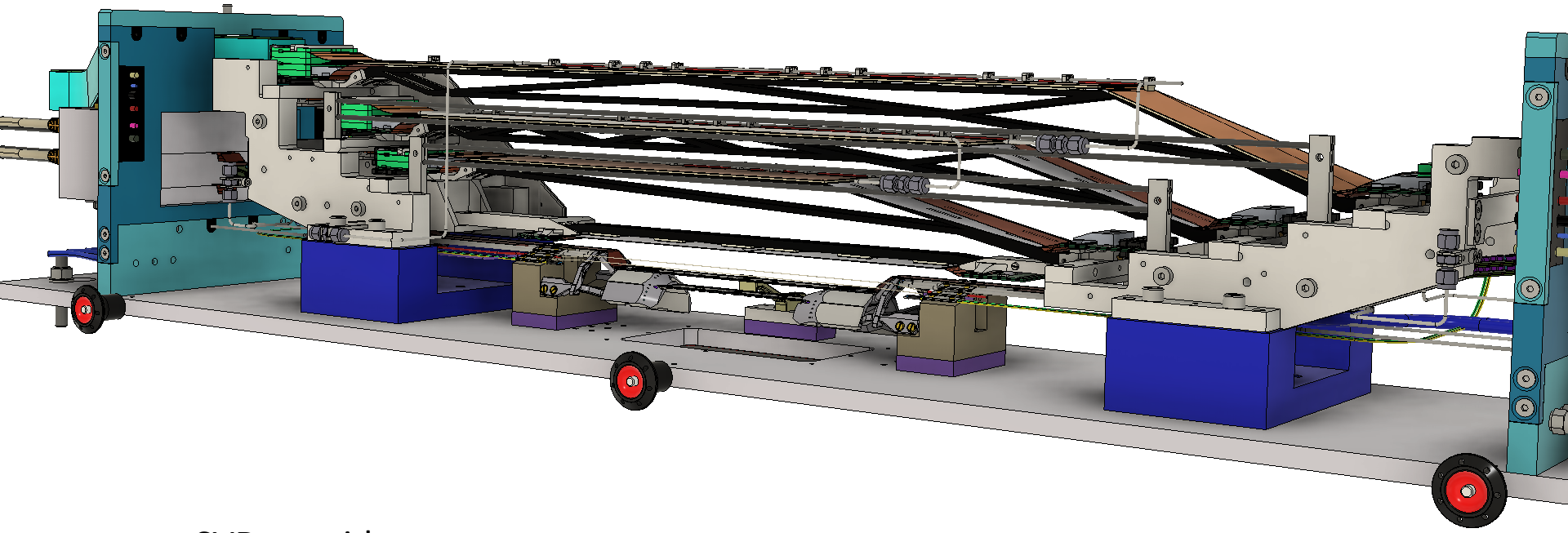
Test Beam Set Up



SVD cartridge

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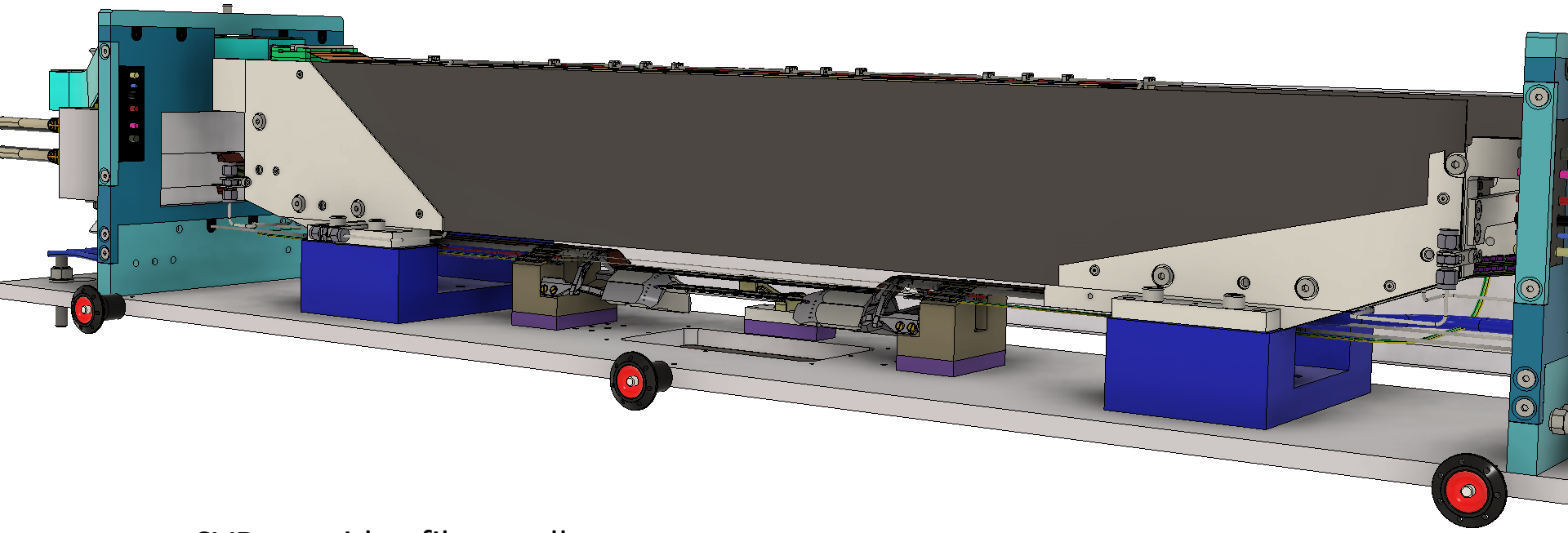
Test Beam Set Up



SVD cartridge fiber walls

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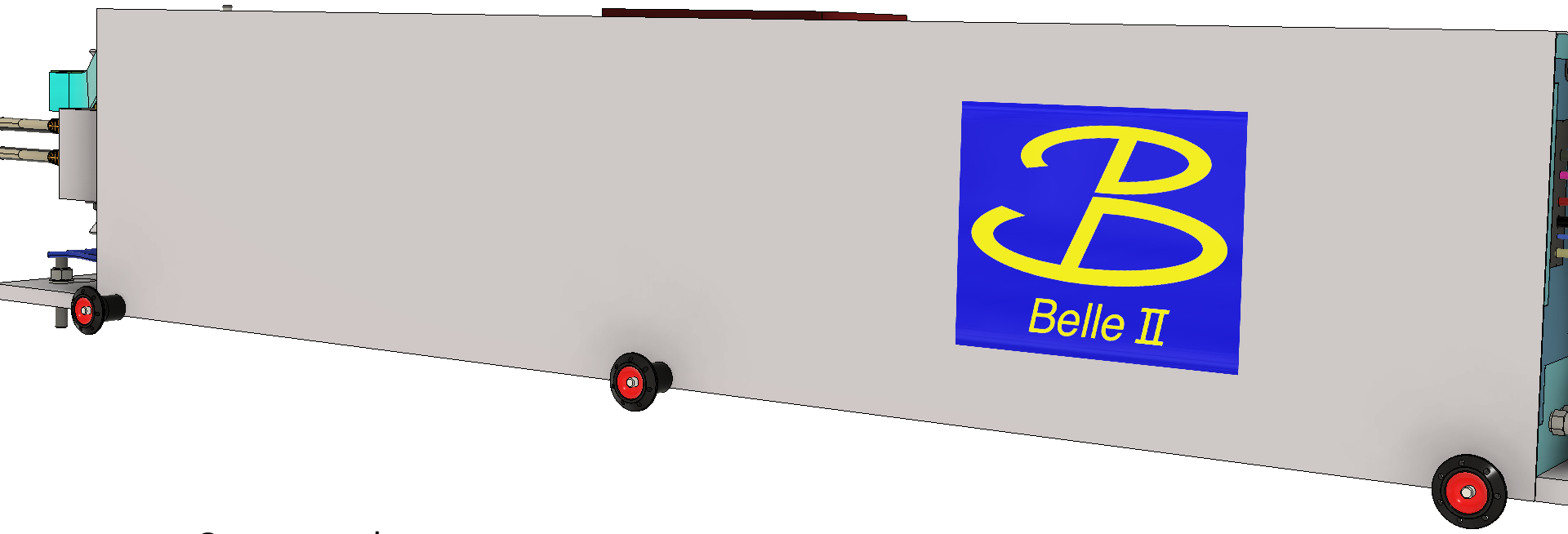
Test Beam Set Up



Outer envelope

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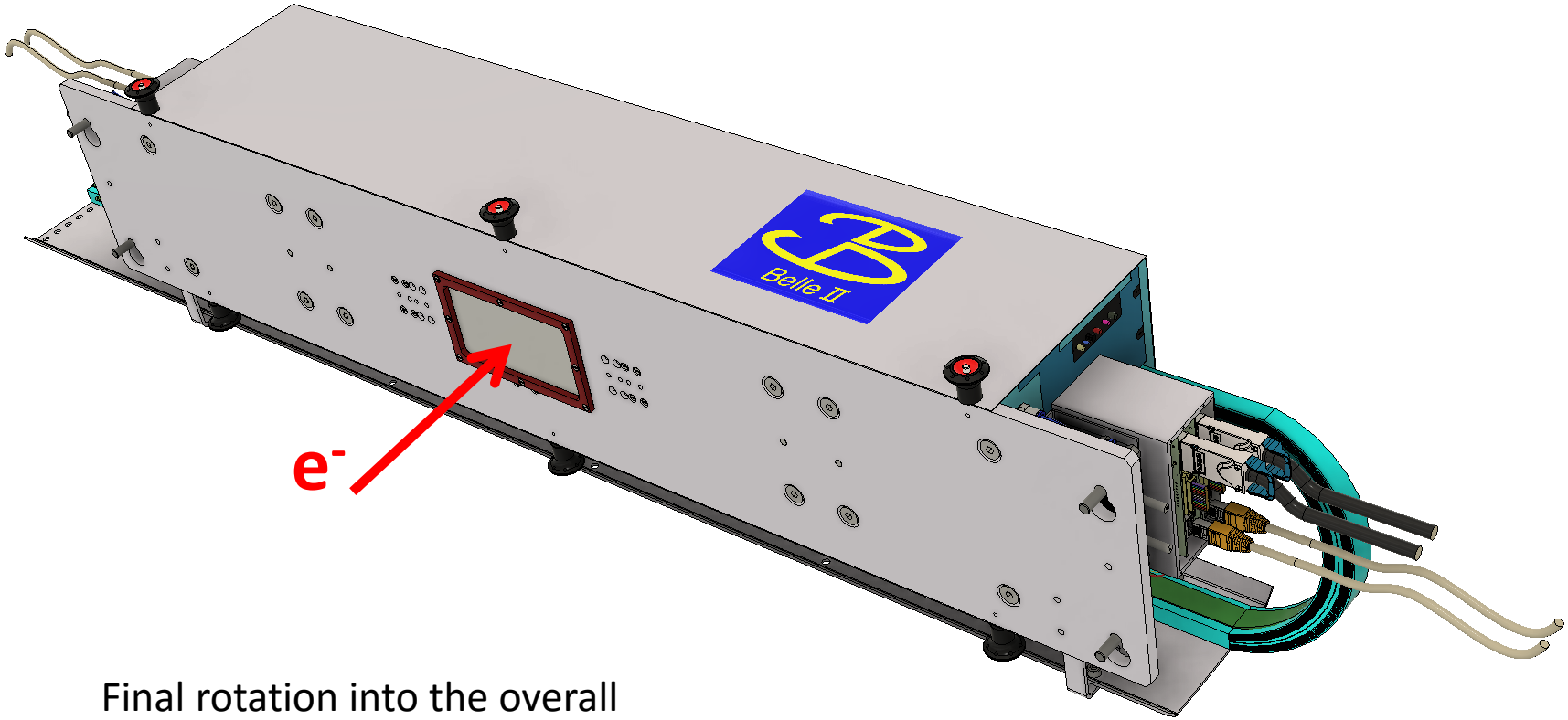
Test Beam Set Up



Final rotation into the overall PCMAG structure

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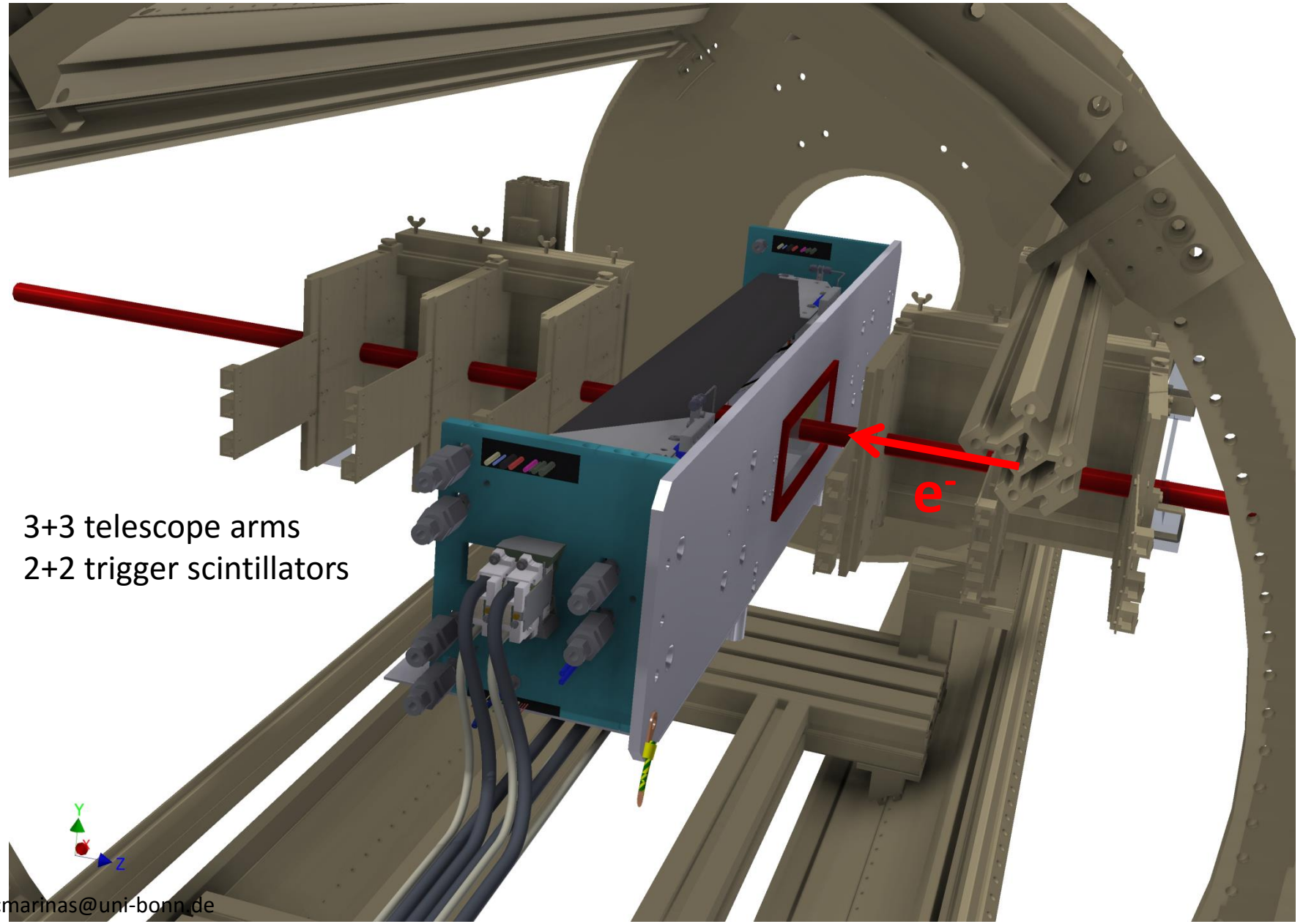
Integration into PCMAG



3+3 telescope arms
2+2 trigger scintillators

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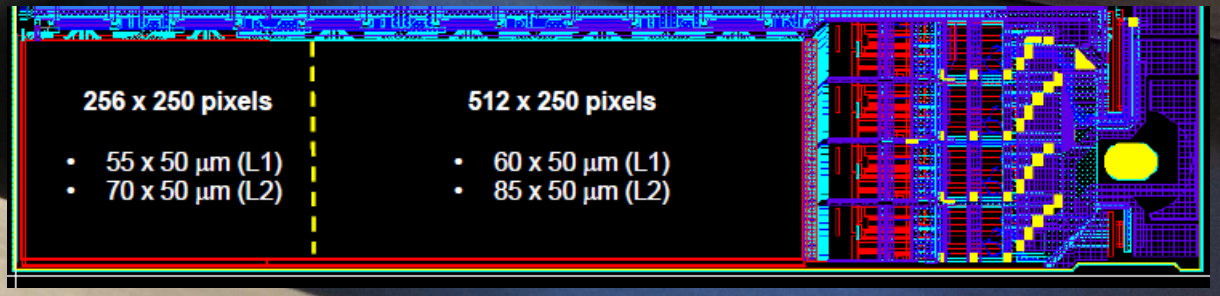
PXD on the SCB



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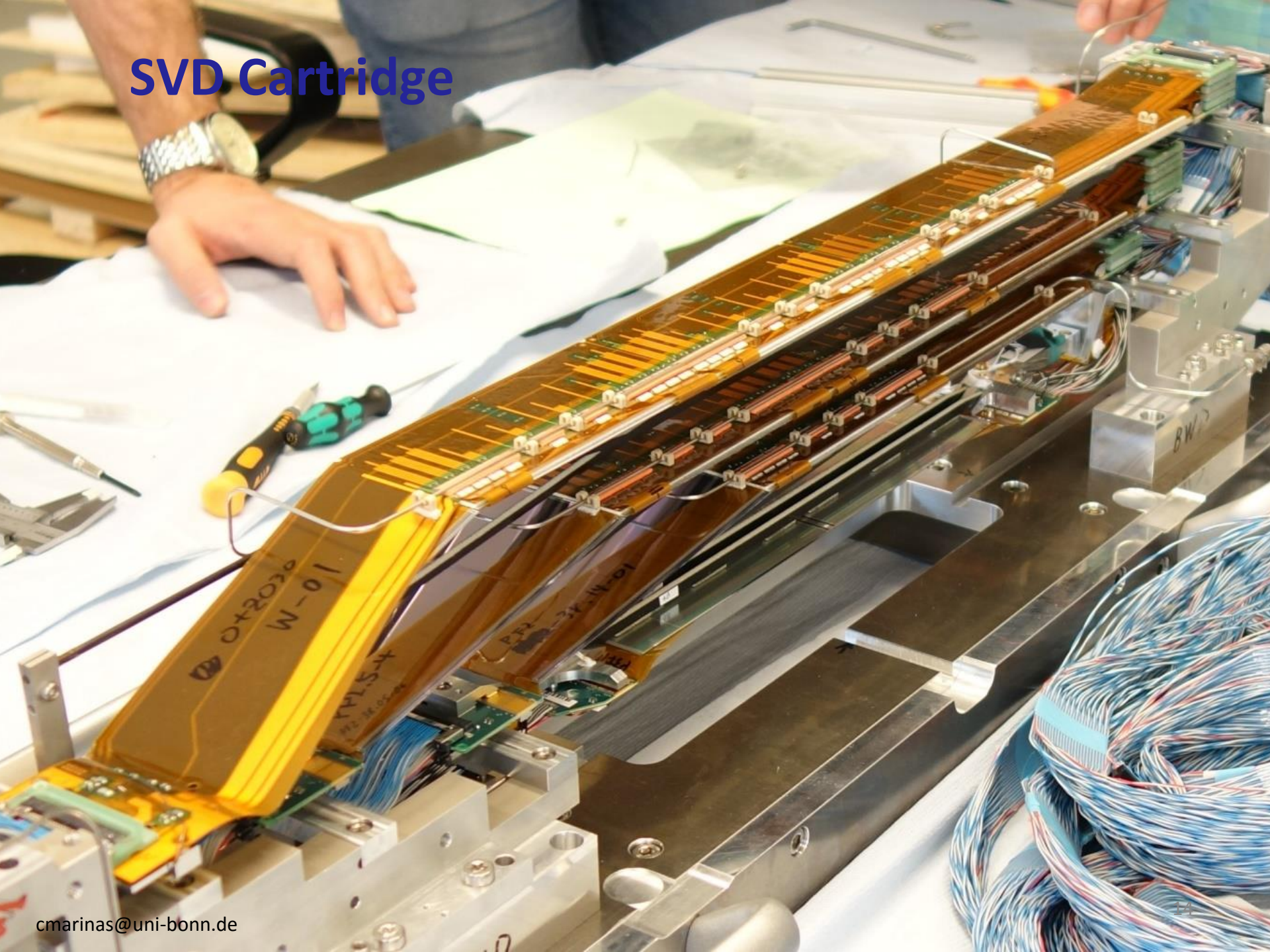
SVD Cartridge



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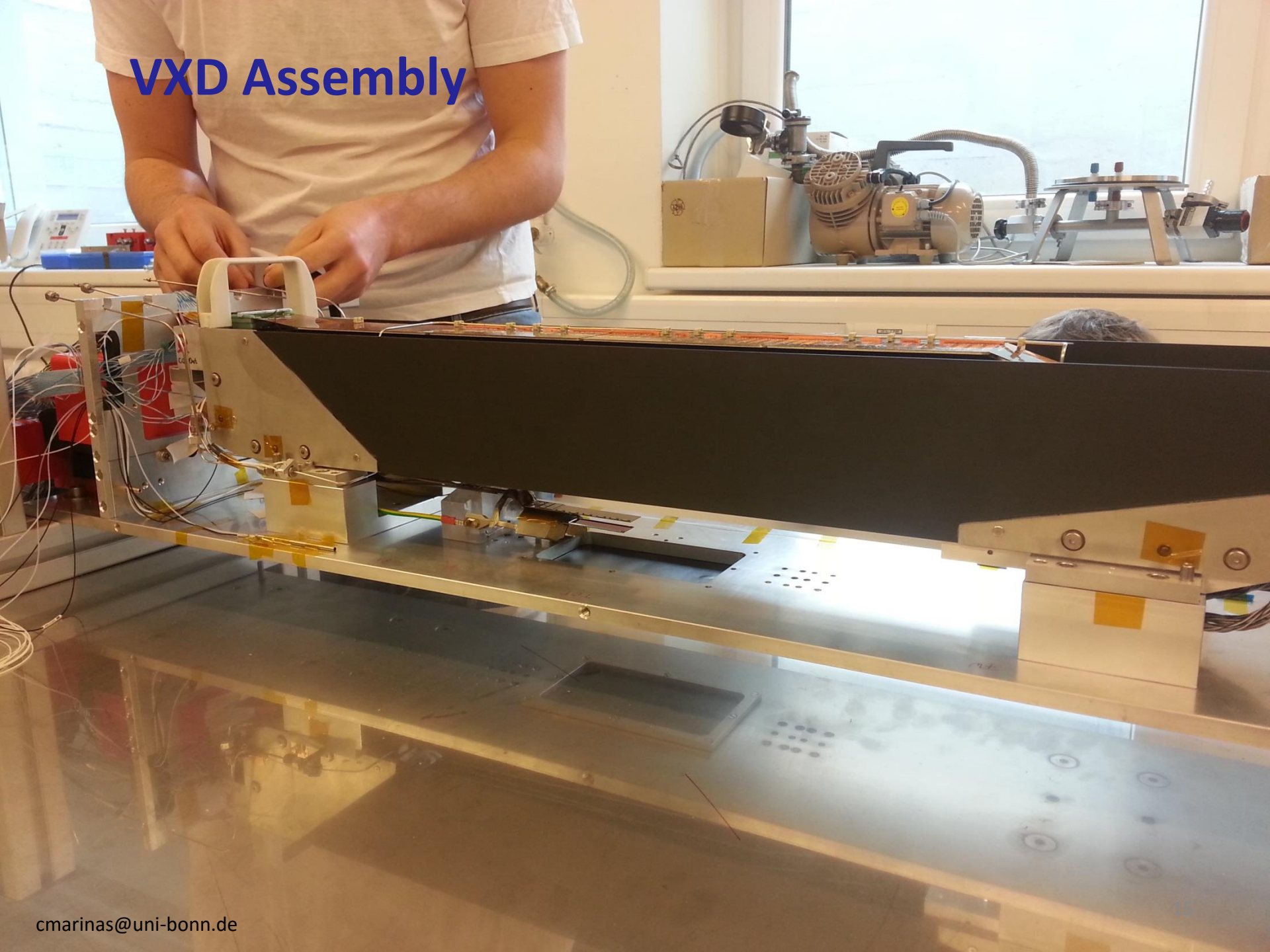
VXD Assembly



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VXD Assembly

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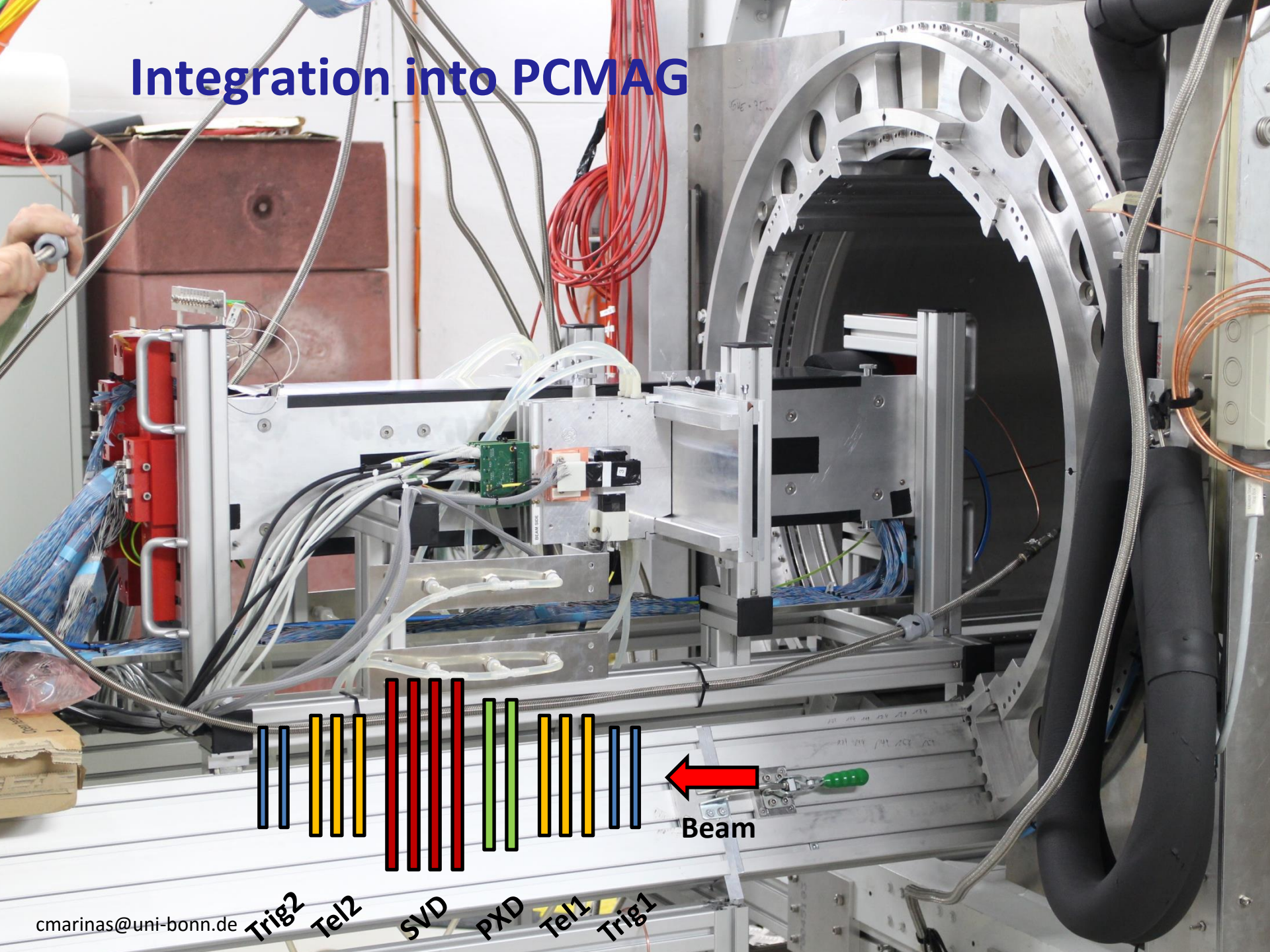
Integration into PCMAG



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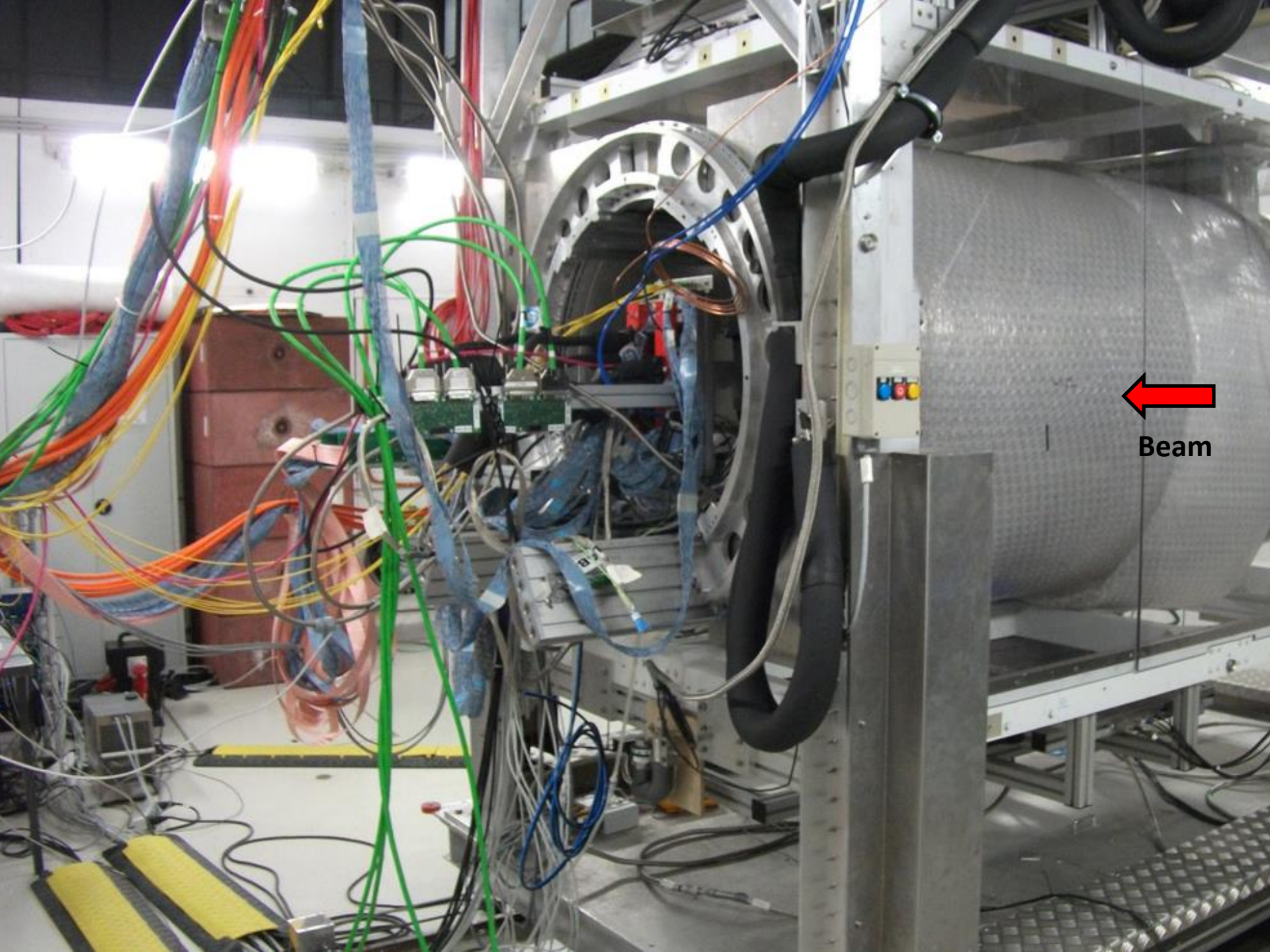
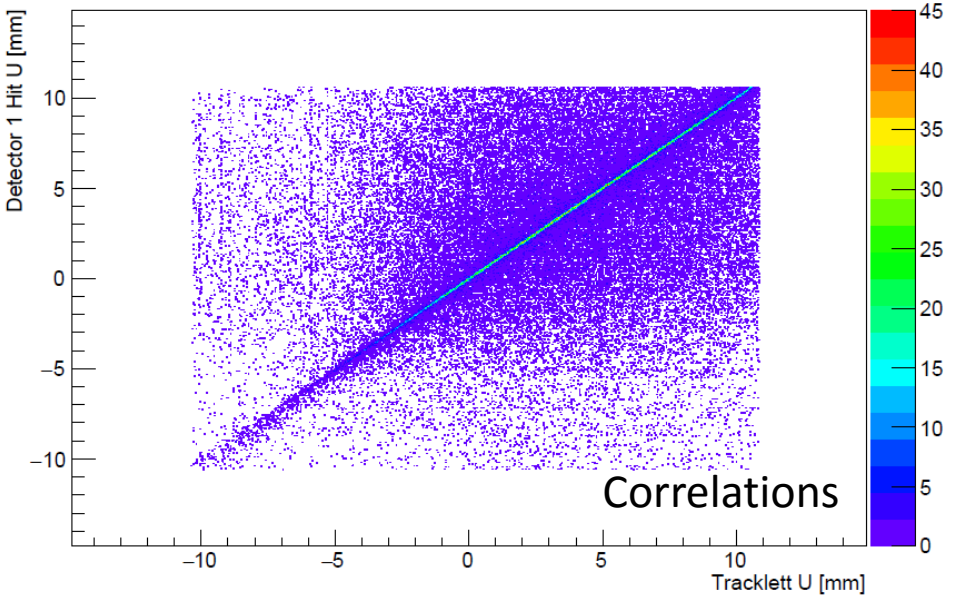
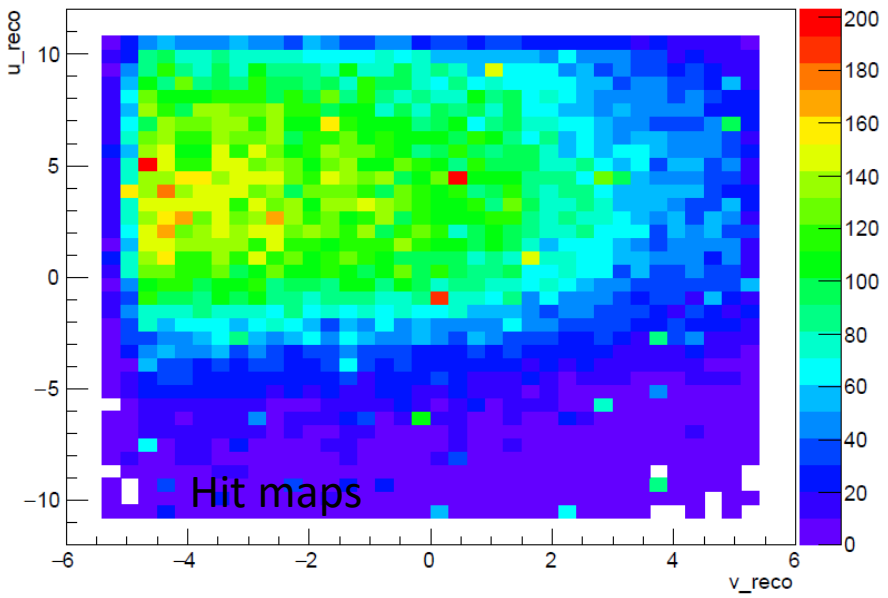
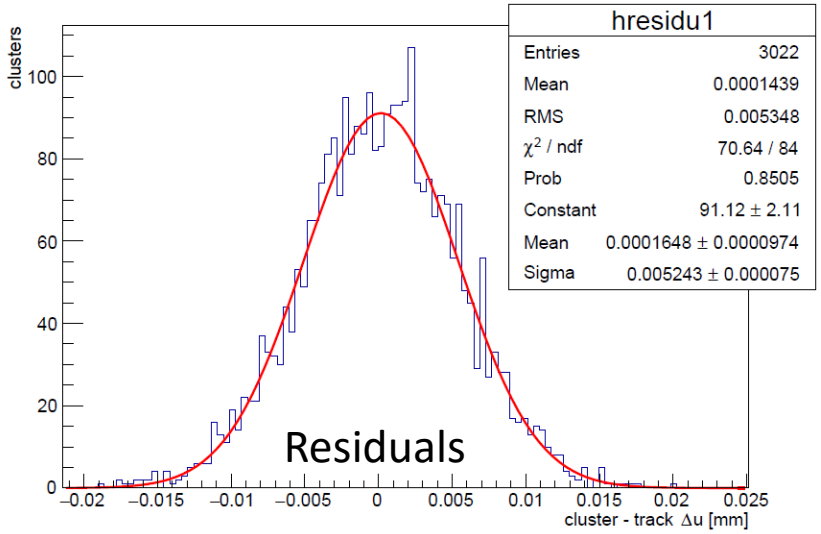

Beam

Alignment. Telescope







- Correlations between telescope arms
- VXD illuminated under electron beam
- Expected residual distributions

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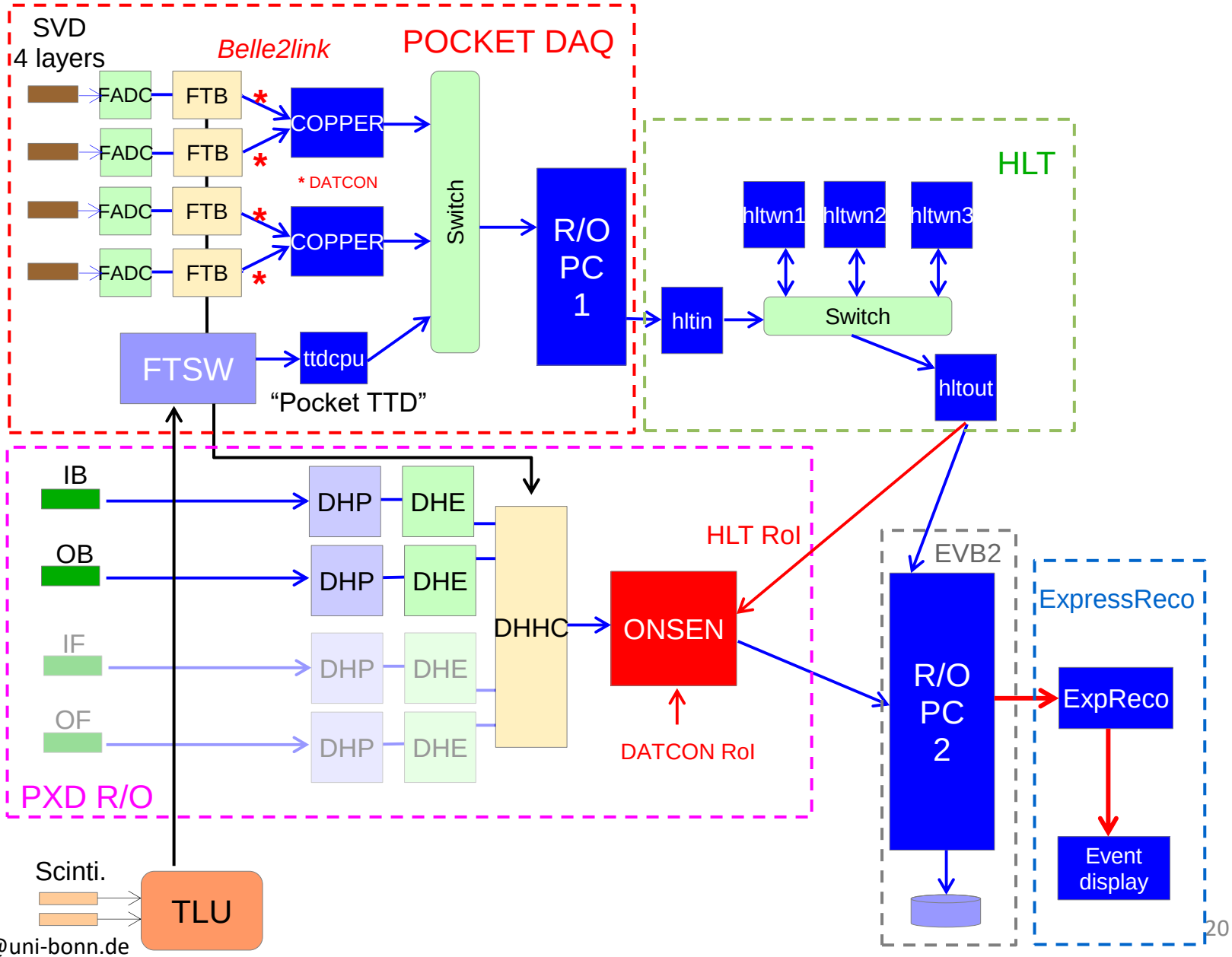
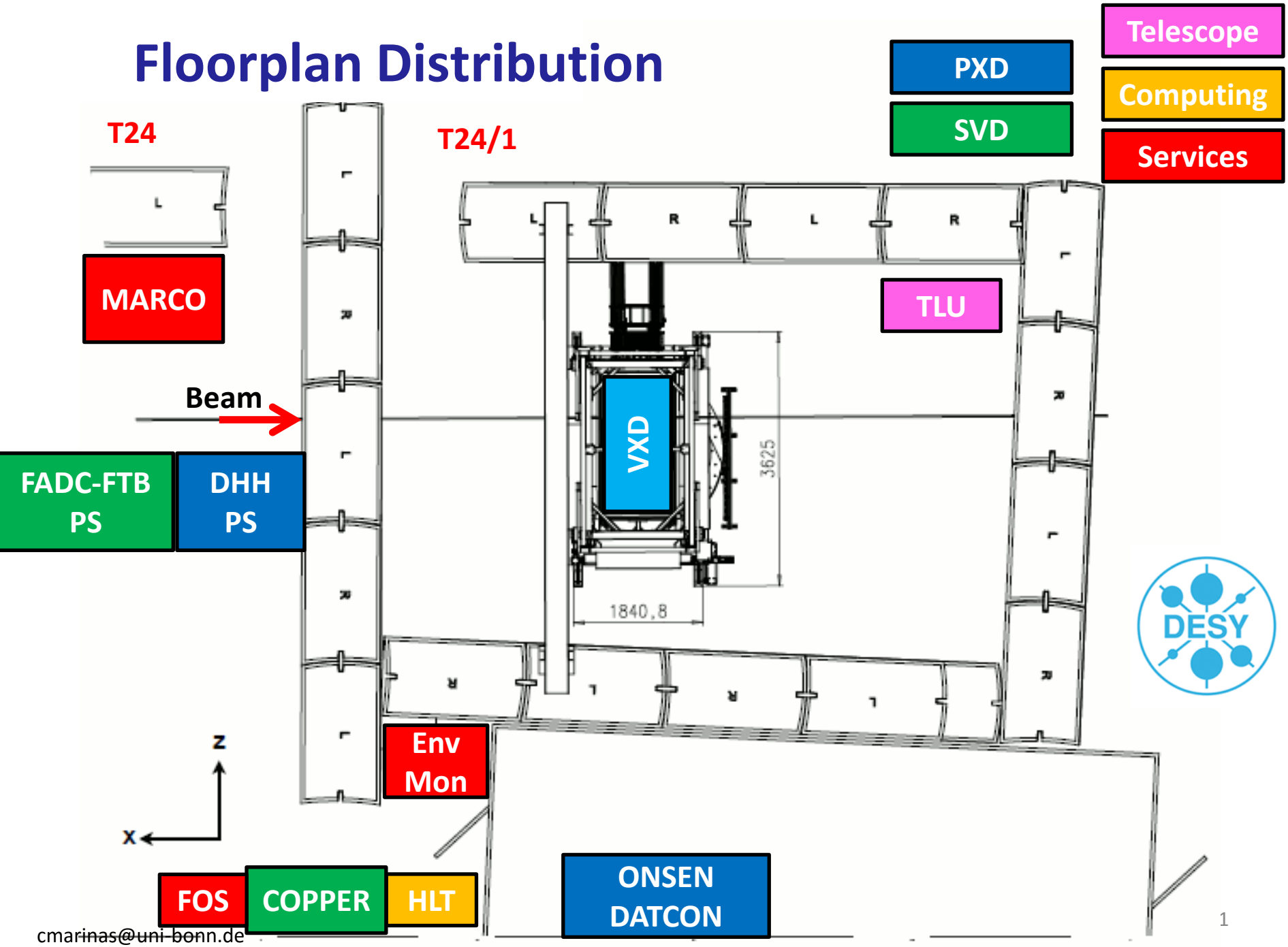
VXD-Test Beam DAQ Structure



Floorplan Distribution



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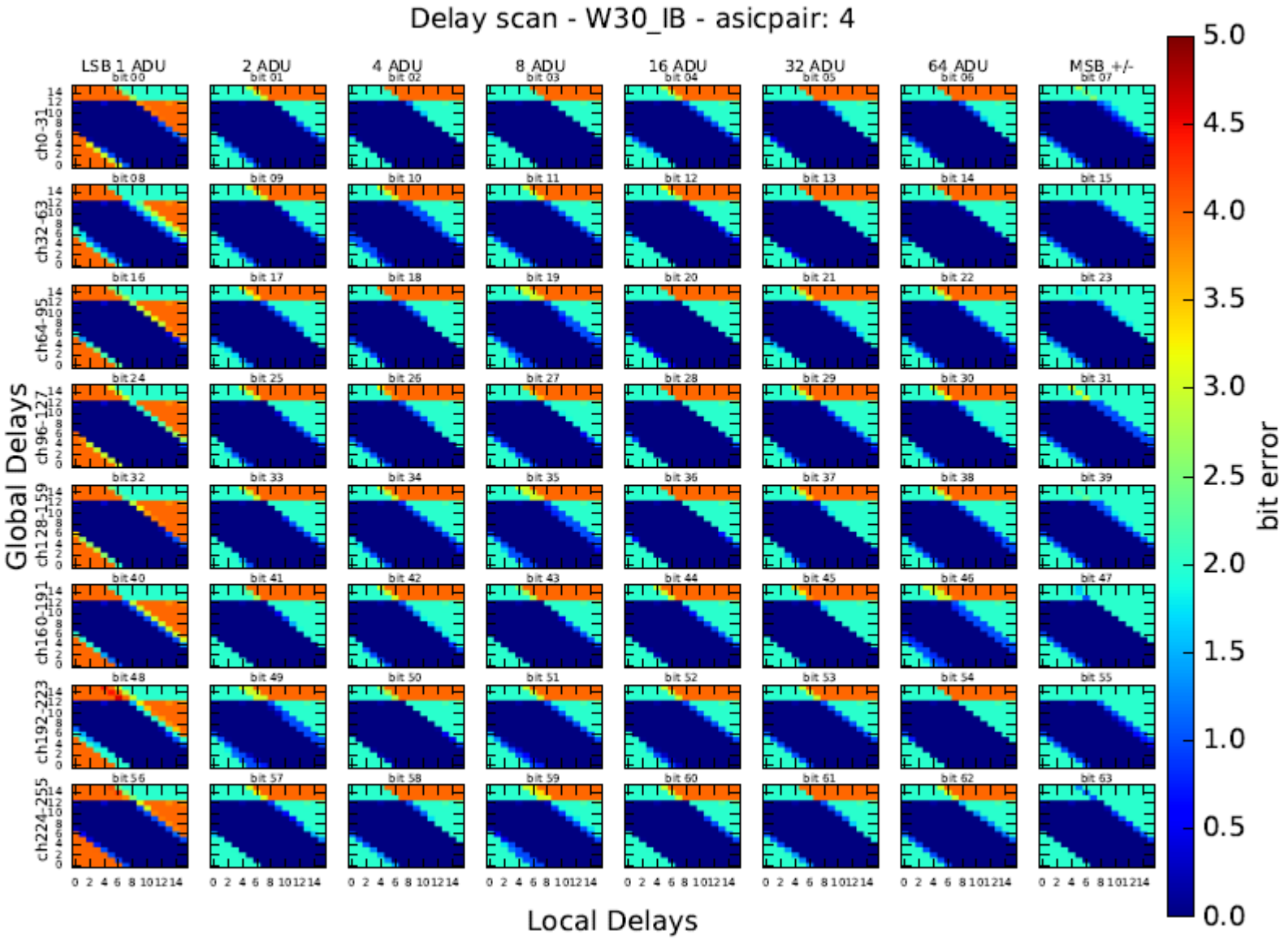
PXD Delays



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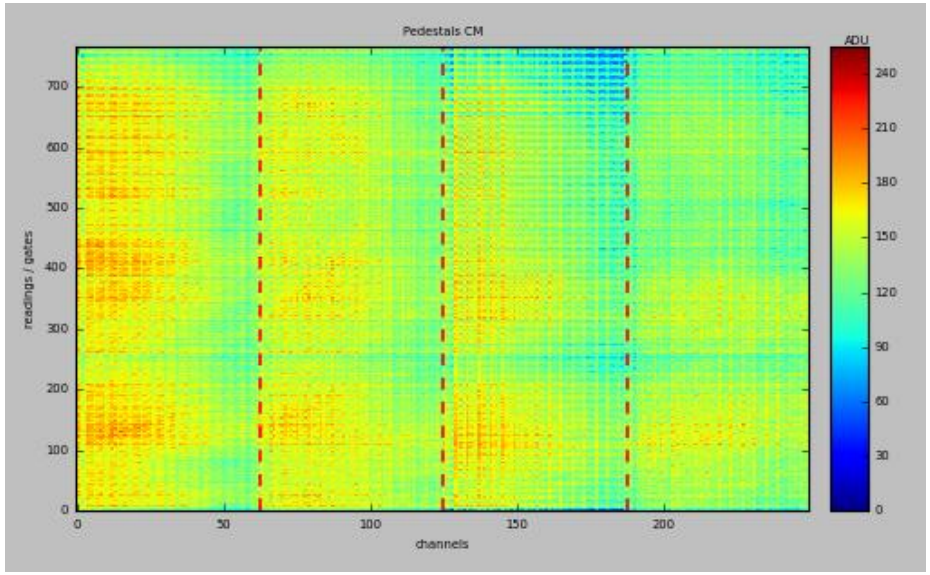
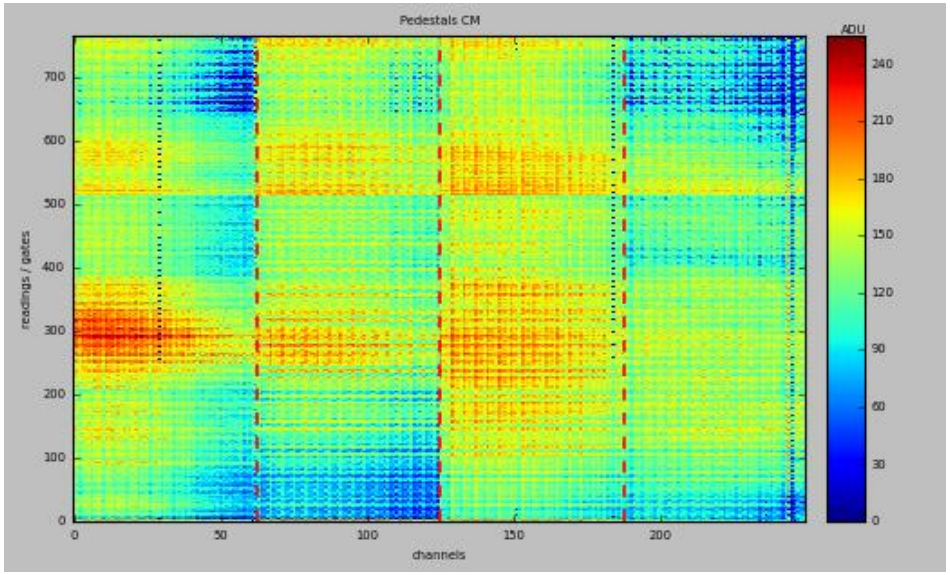
PXD Pedestal Distributions



IB



OB

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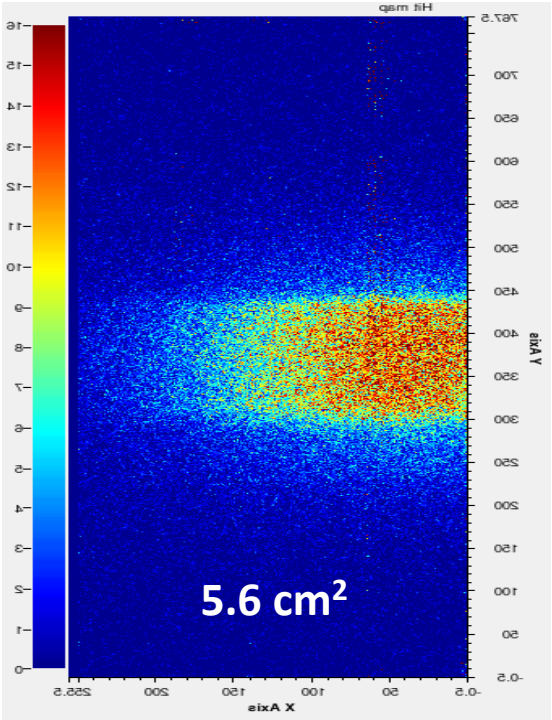
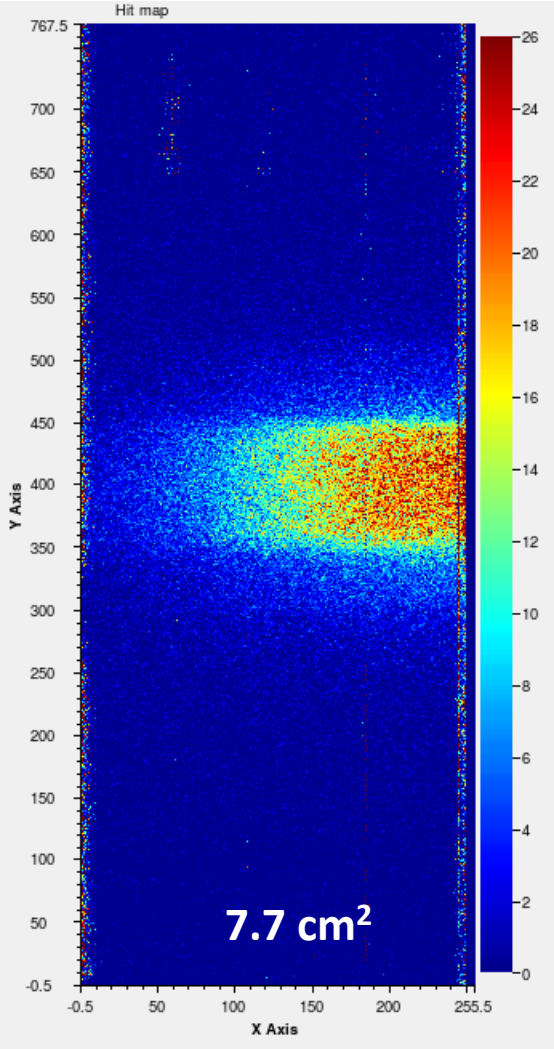
PXD Hit Maps

Threshold = 5 (~ 1200 electrons)



Inner Backward



Outer Backward

Trigger on 4 scintillators
Collimated beam
No magnetic field

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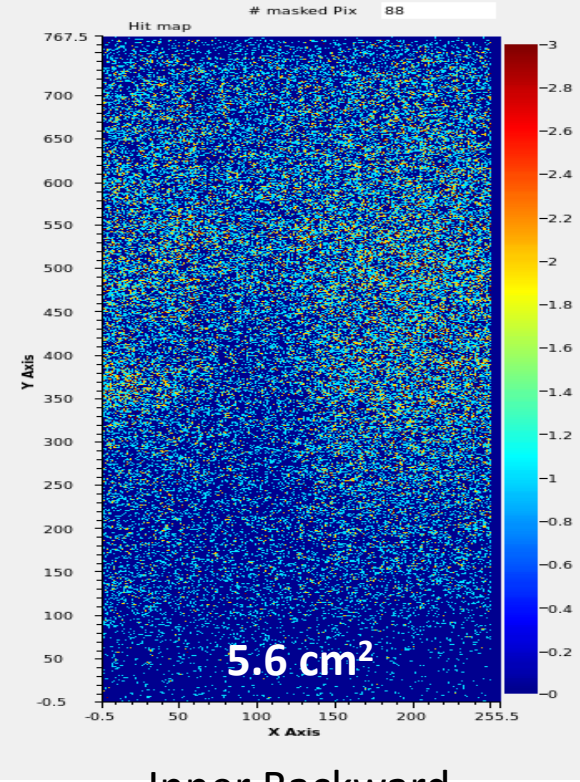
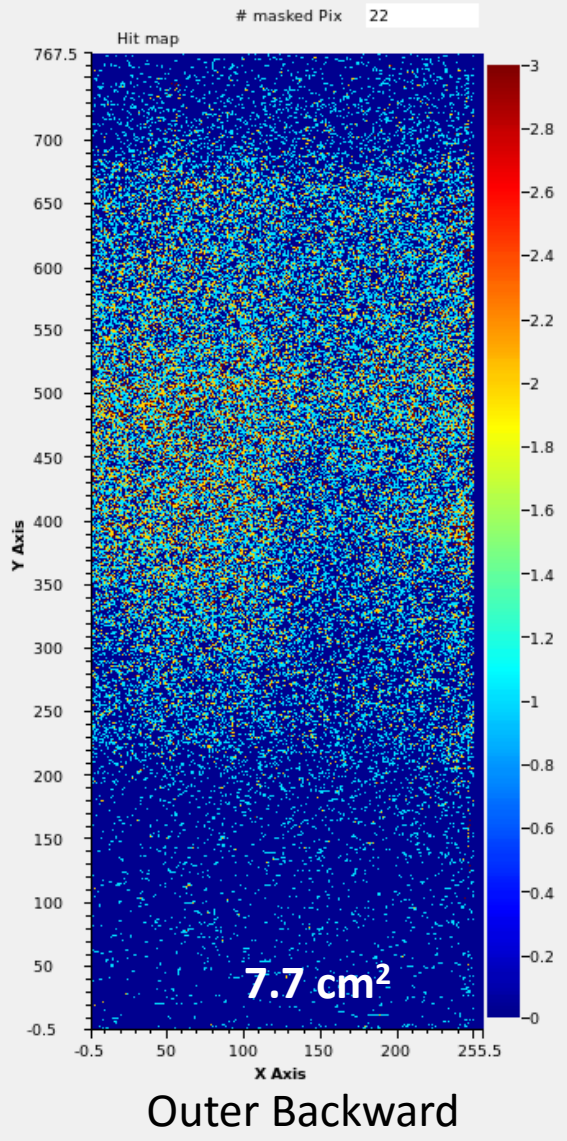
PXD Hit Maps (B=1T)

Threshold = 5 (~ 1200 electrons)



Inner Backward



Outer Backward

Trigger on 2 big scintillators
No collimation system
1 T magnetic field

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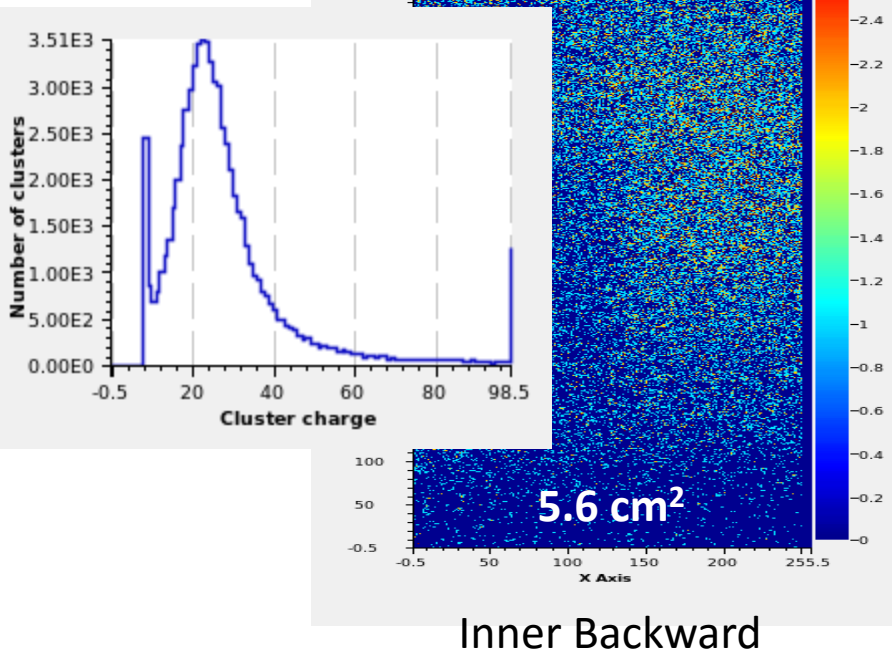
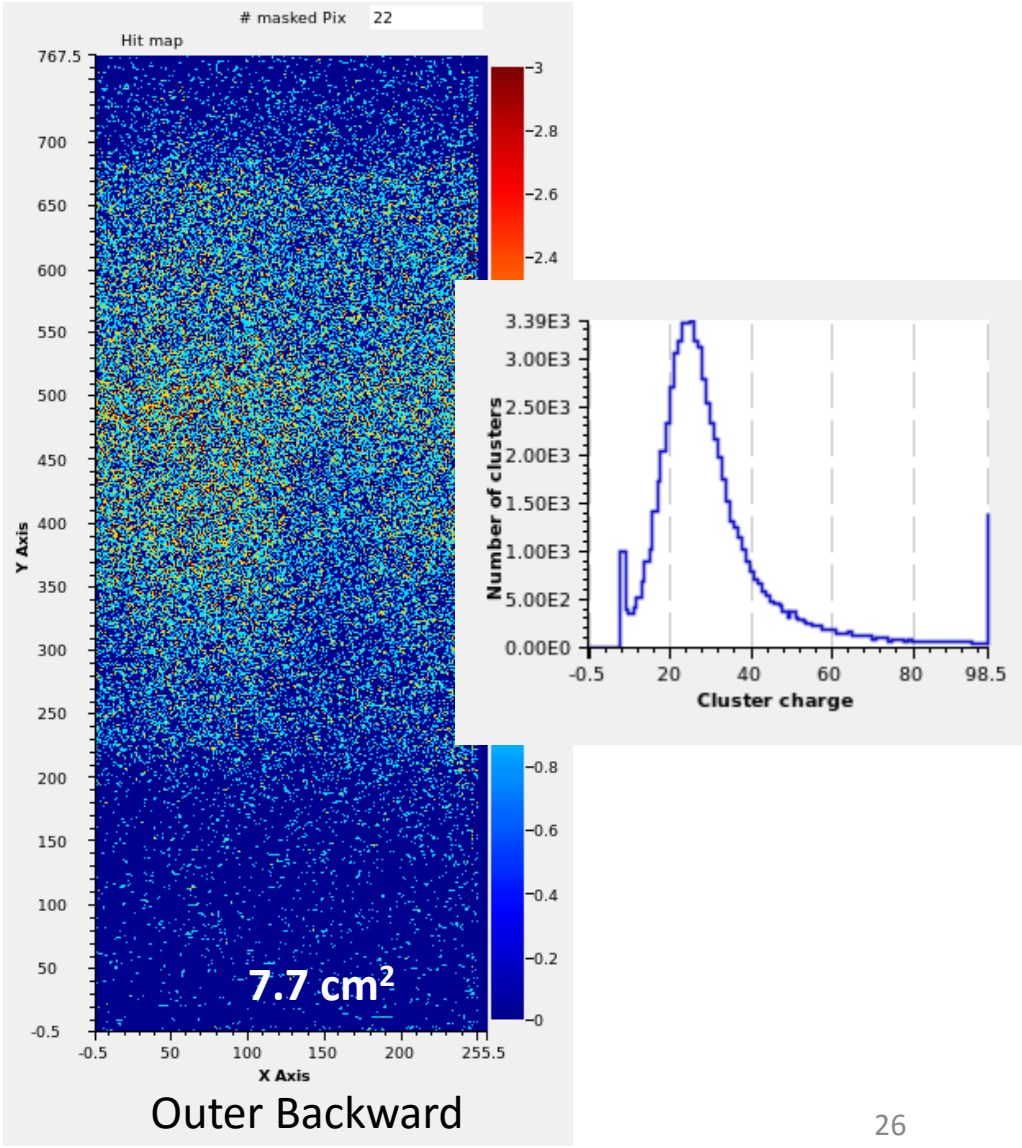
PXD Hit Maps (B=1T)

Threshold = 5 (~ 1200 electrons)



Inner Backward



Outer Backward

Trigger on 2 big scintillators
No collimation system
1 T magnetic field

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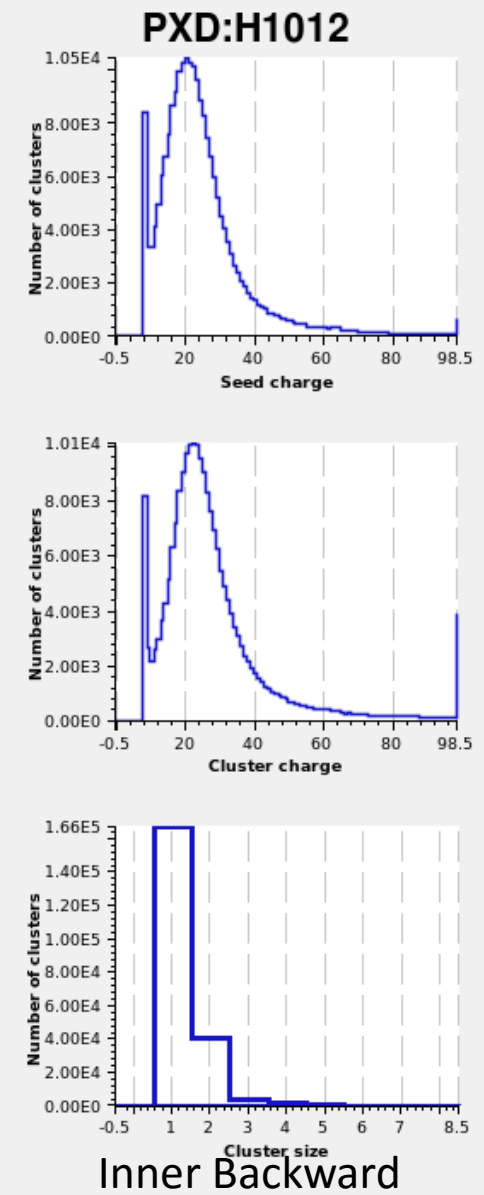
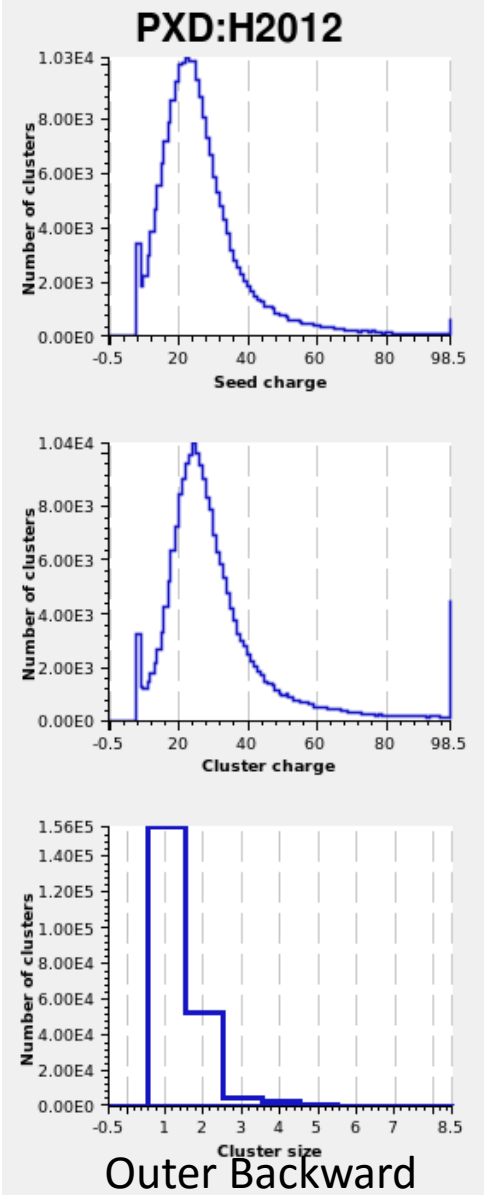
PXD Signals



Inner Backward

SNR ~ 32 for perpendicular incident MIPs



Outer Backward

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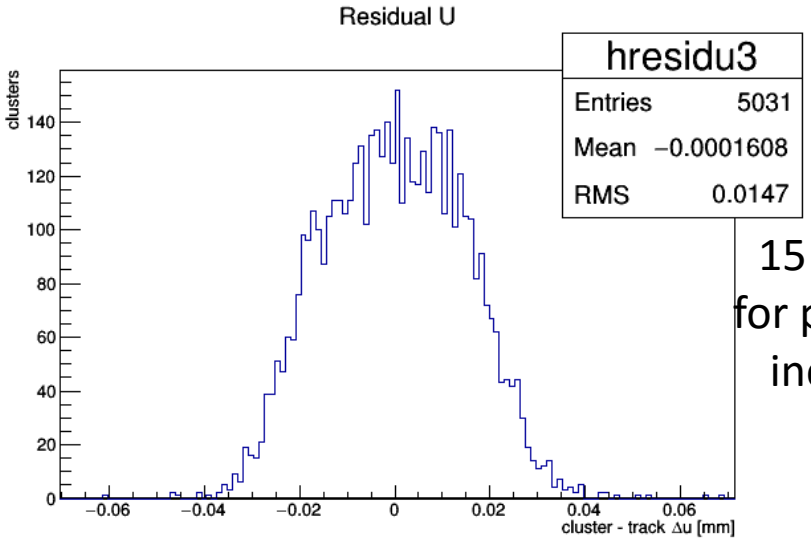
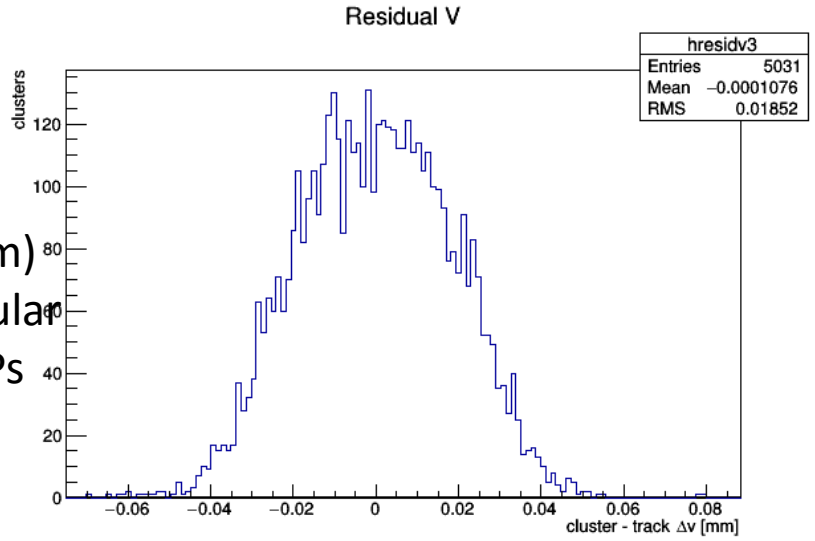
PXD Residuals



15 µm (18 µm) for perpendicular incident MIPs



Inner Backward

Outer Backward

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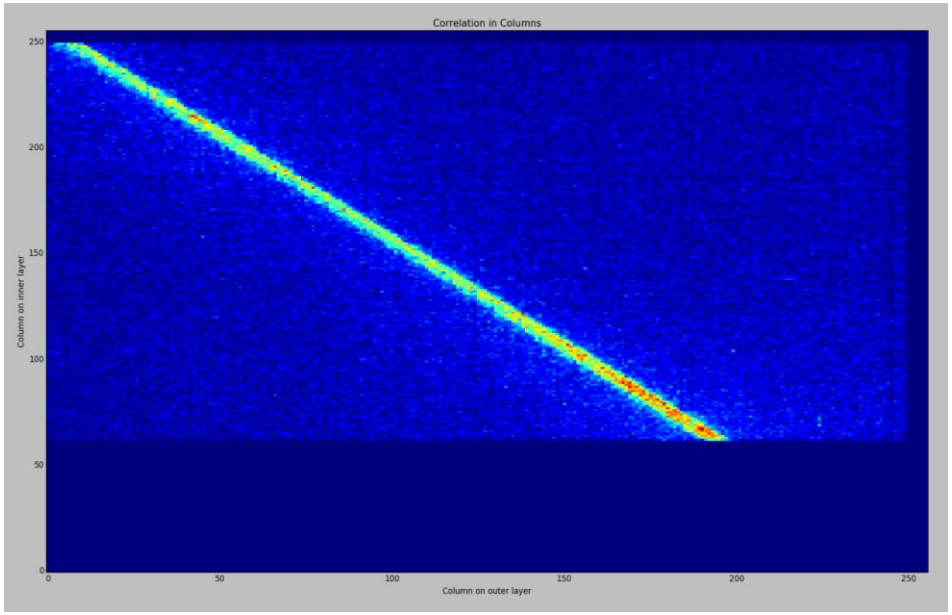
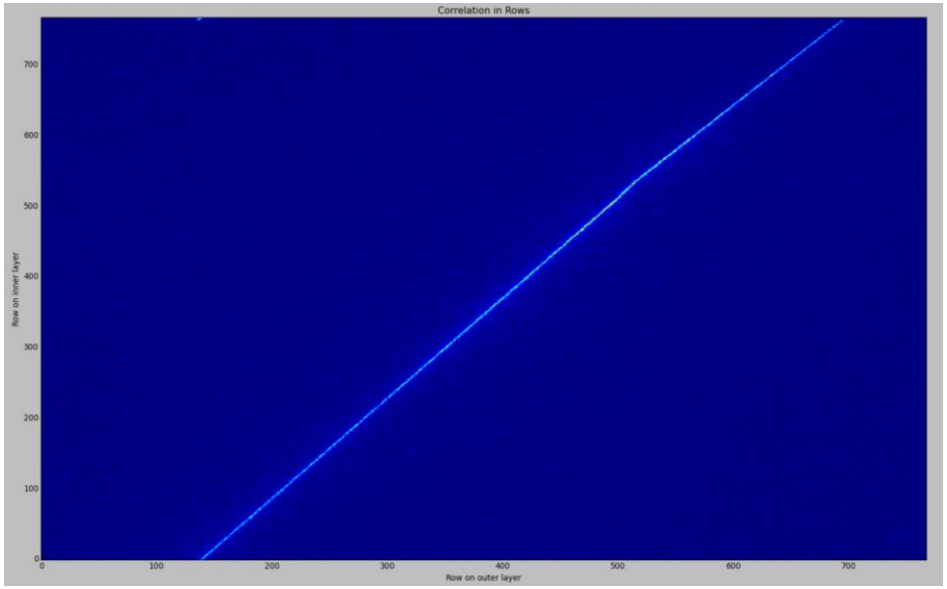
PXD Correlations



- Mapping correct
- Proper timing



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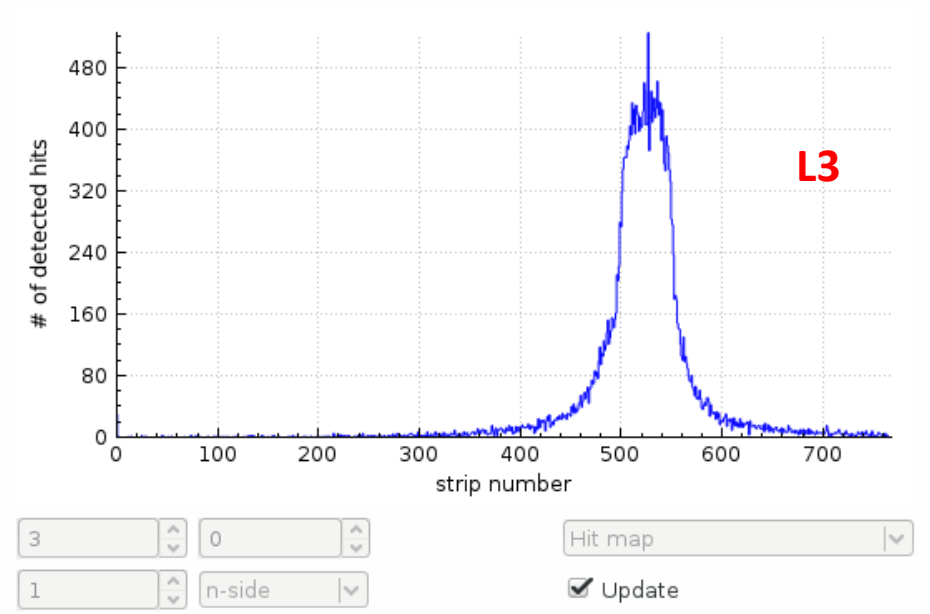
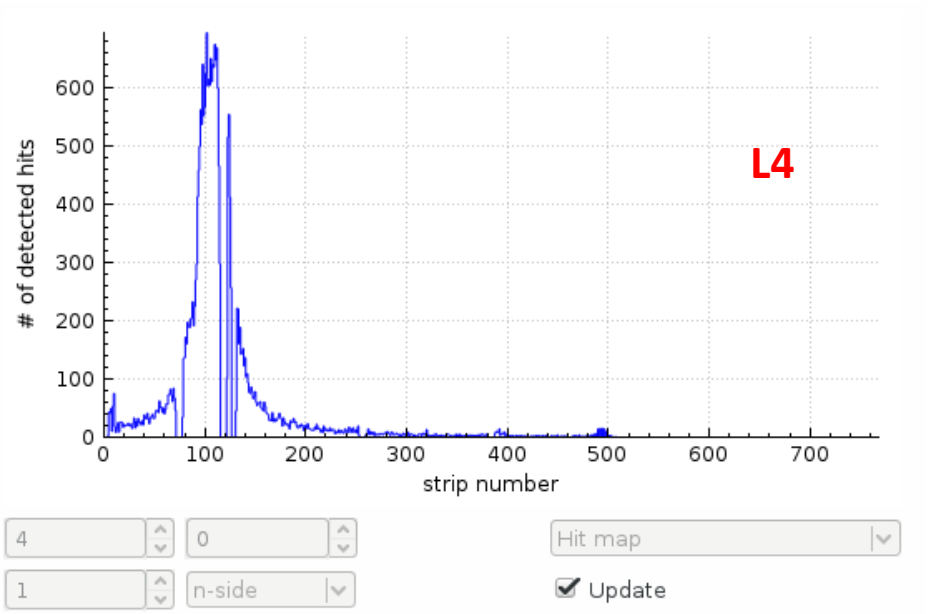
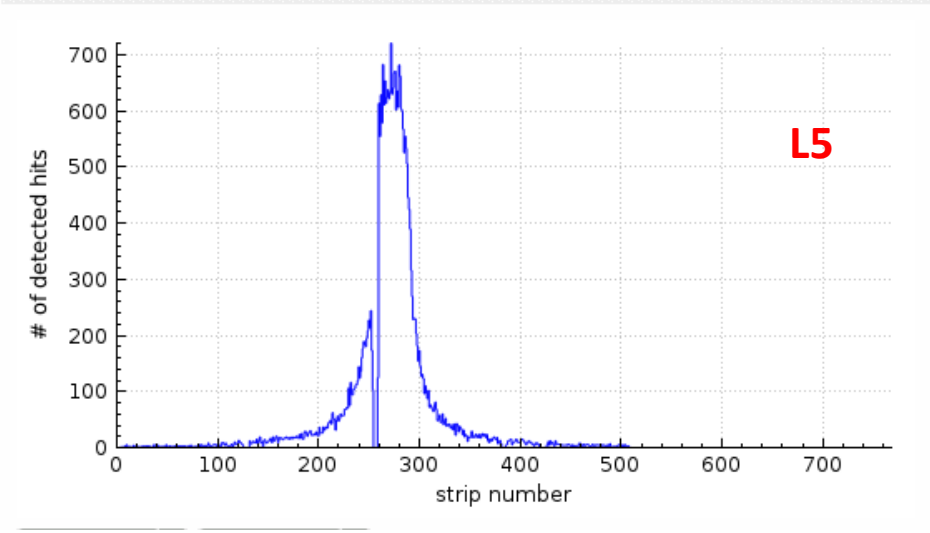
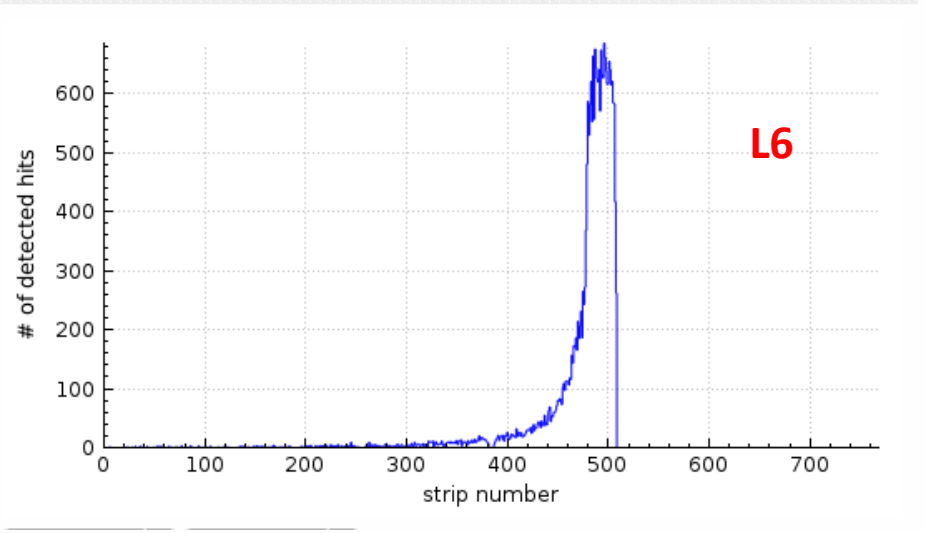
SVD Hit Maps (n-side)









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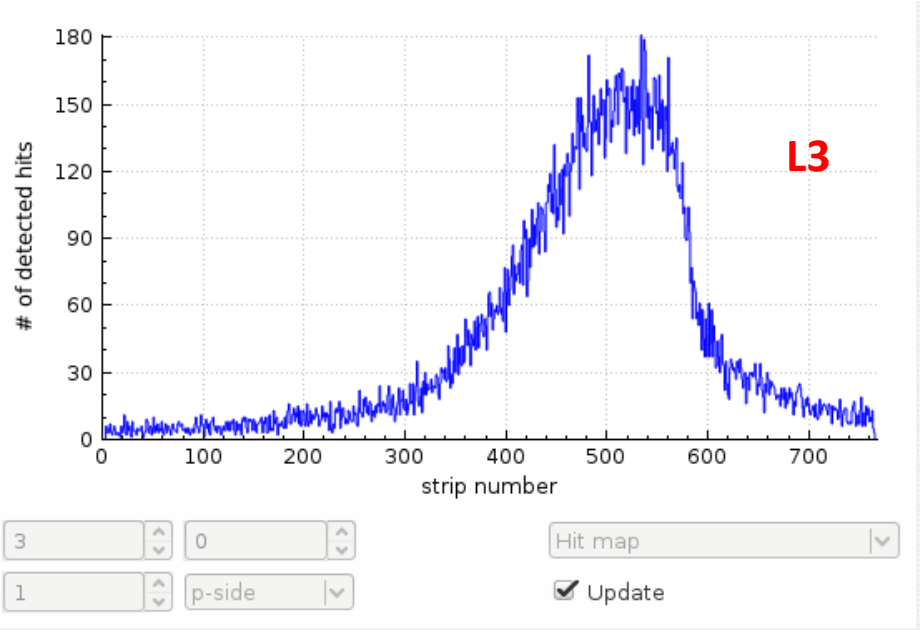
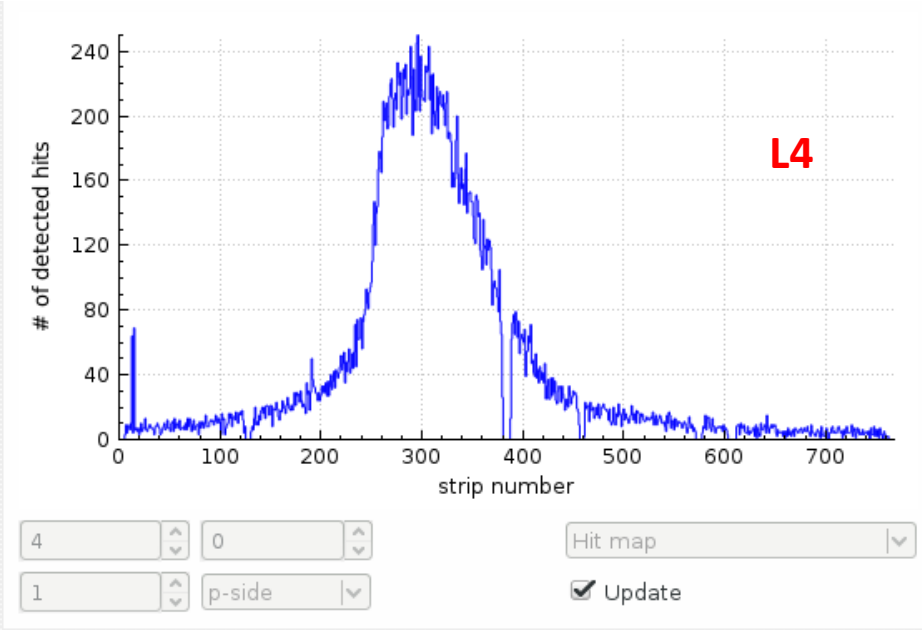
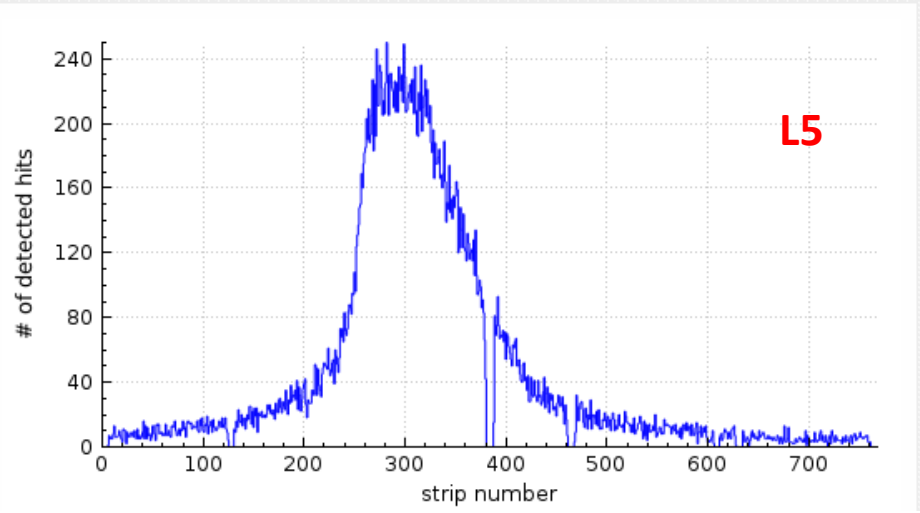
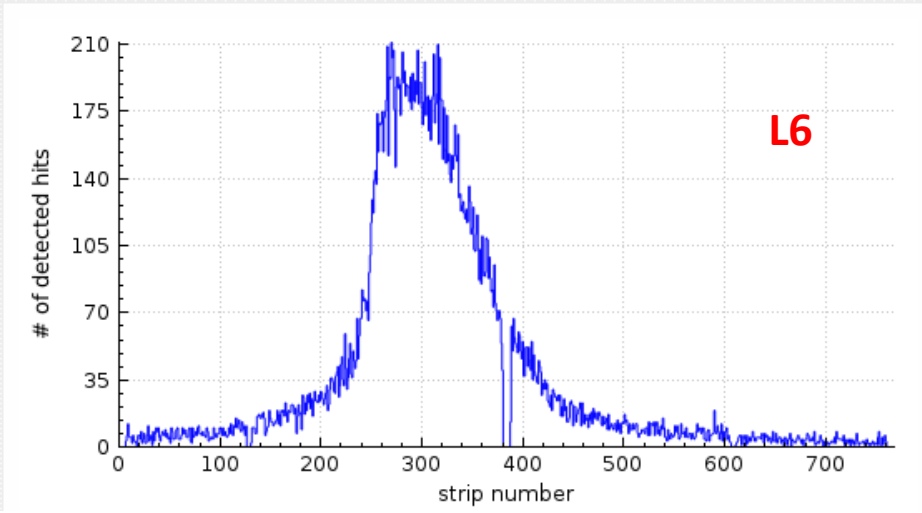
SVD Hit Maps (p-side)









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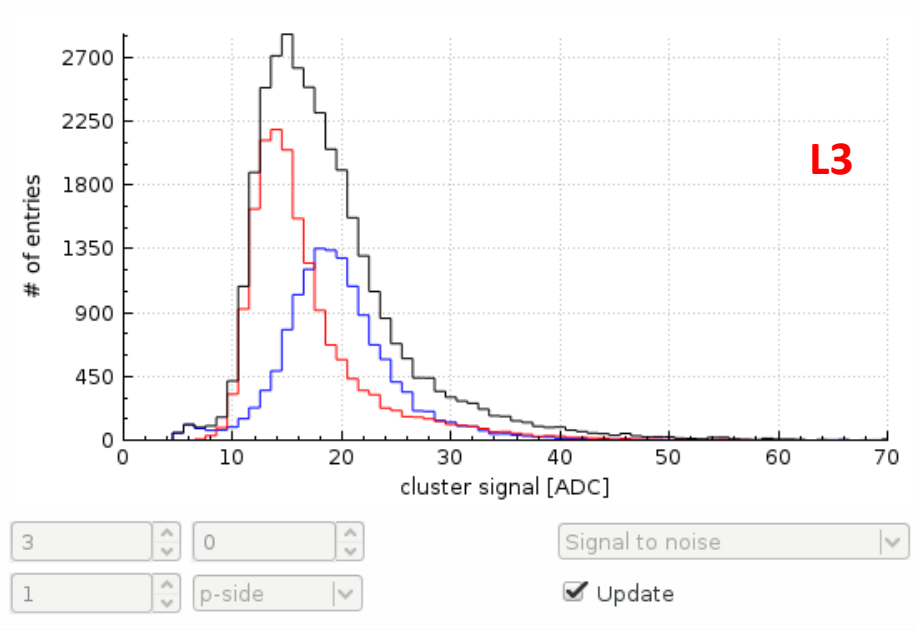
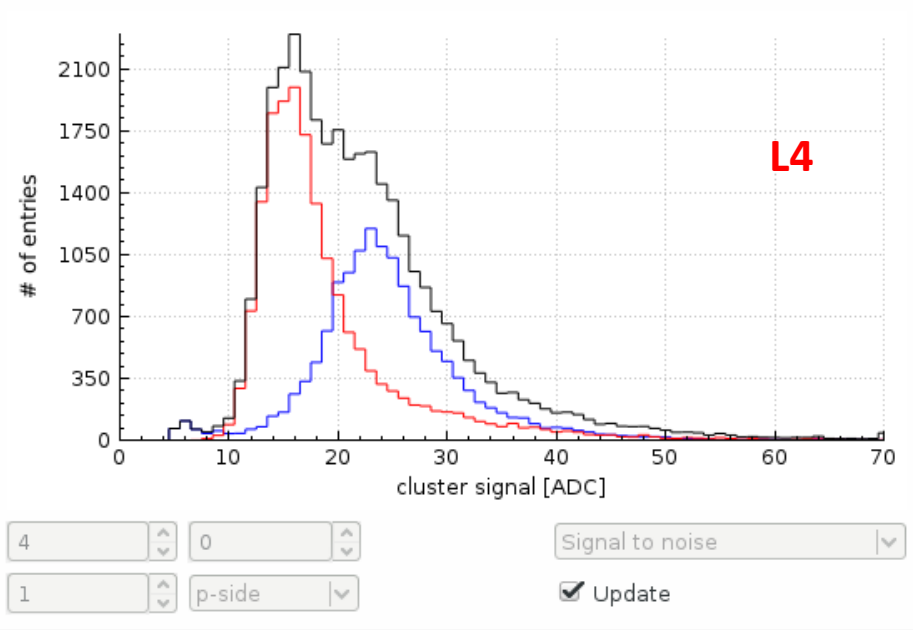
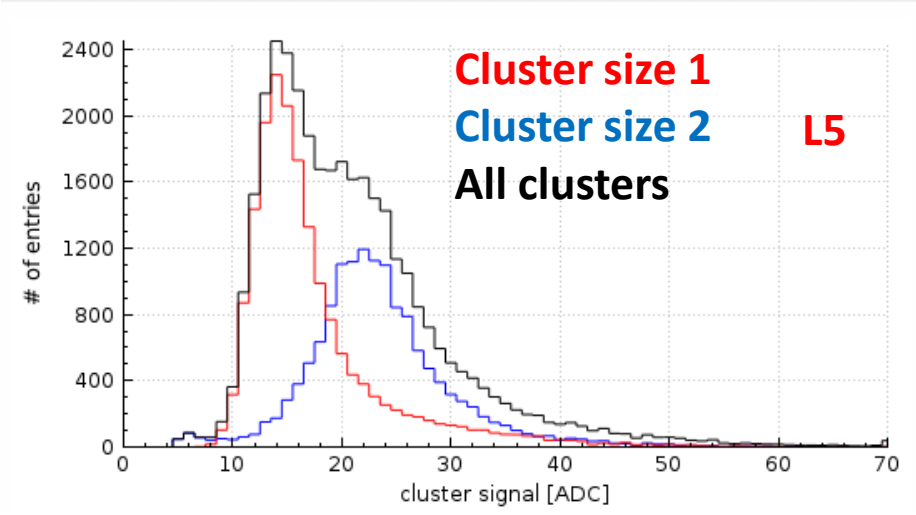
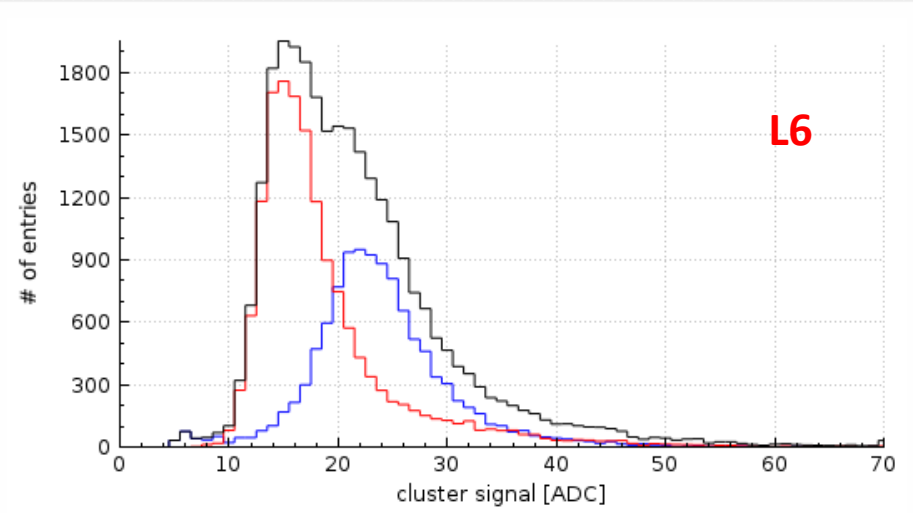
SVD Signal-to-Noise (p-side)

p-side ~ 14…22









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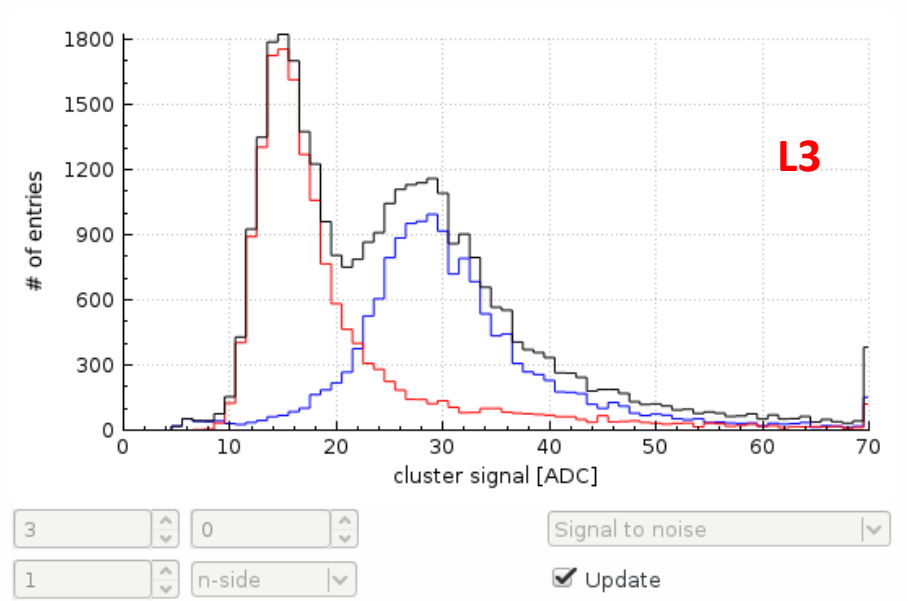
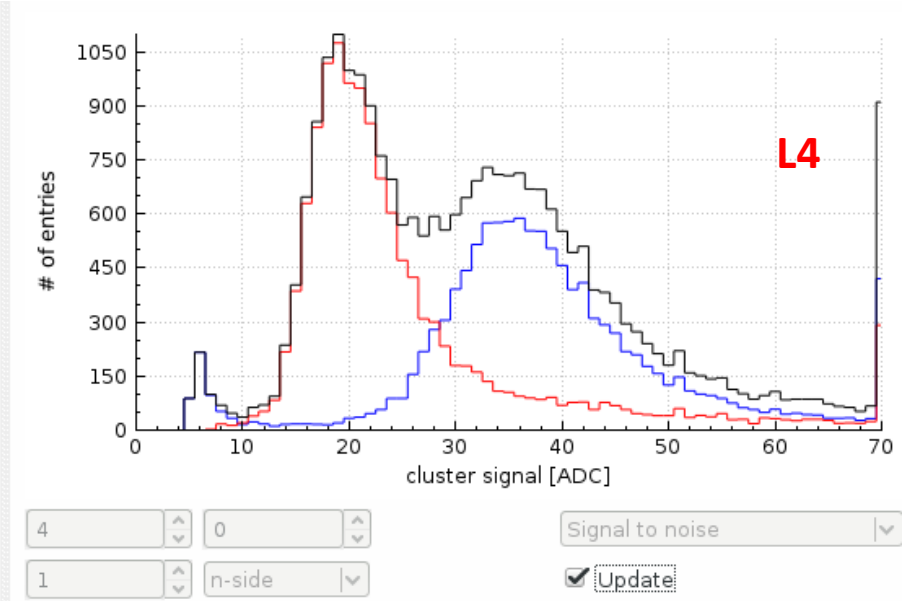
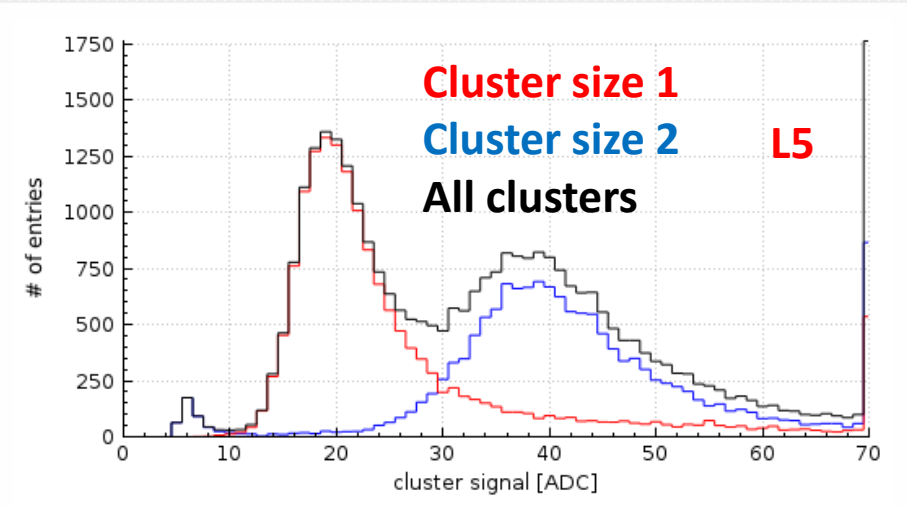
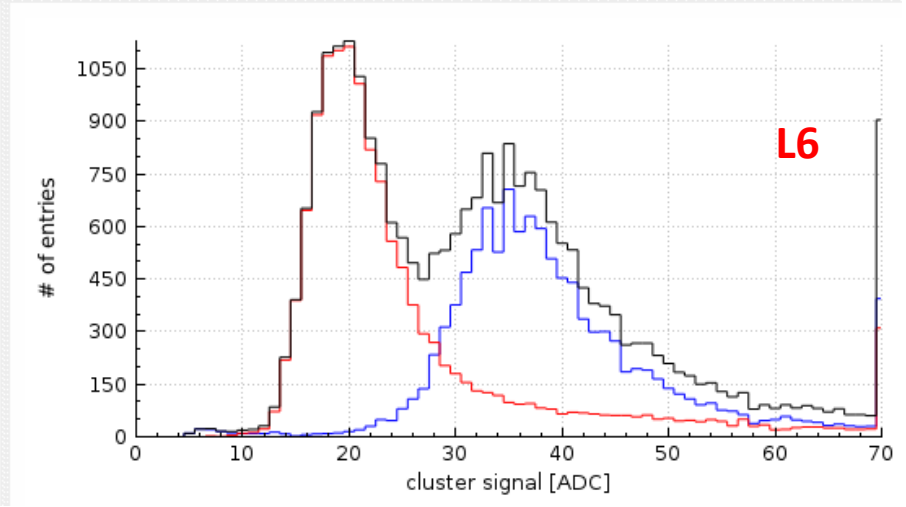
SVD Signal-to-Noise (n-side)

n-side ~ 14…38









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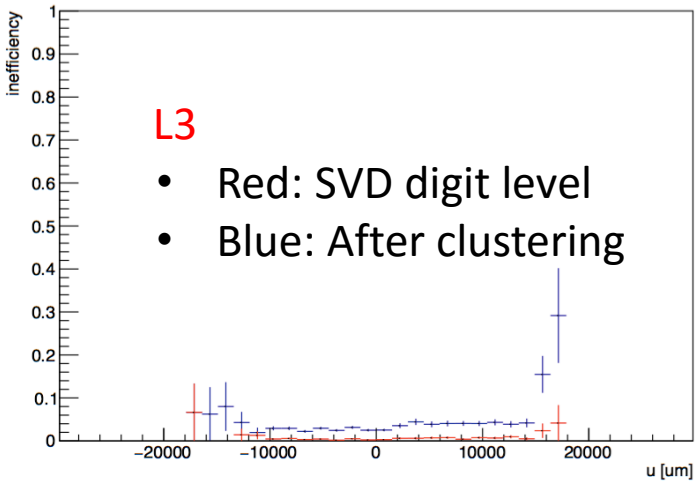
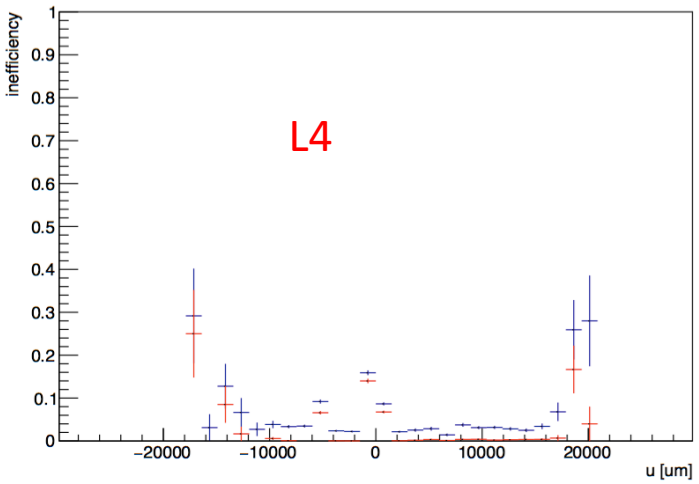
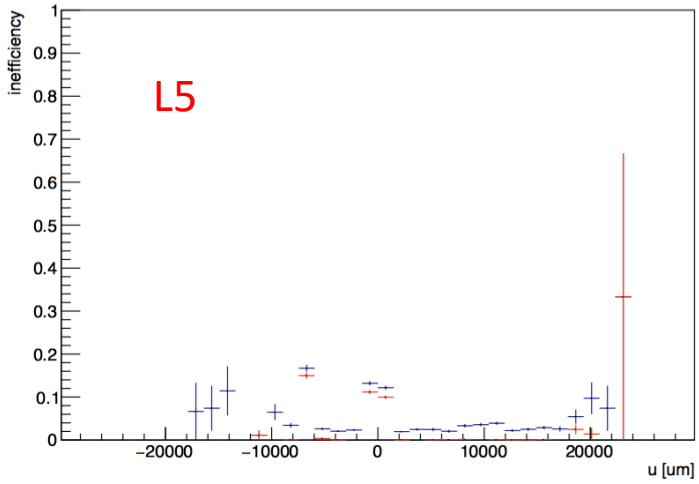
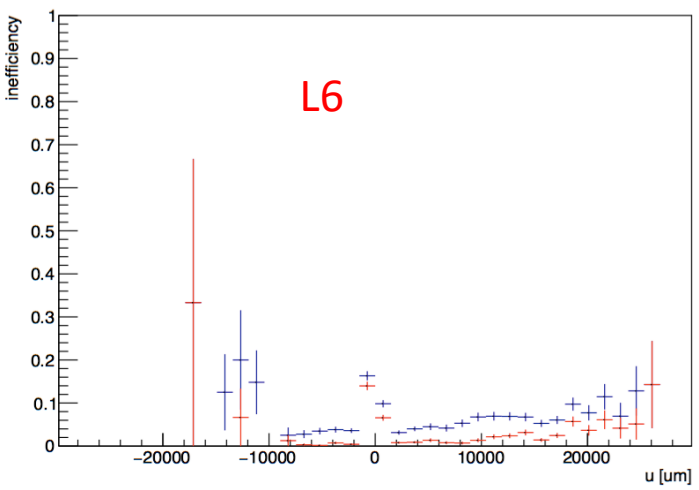
SVD Inefficiency (u-side)









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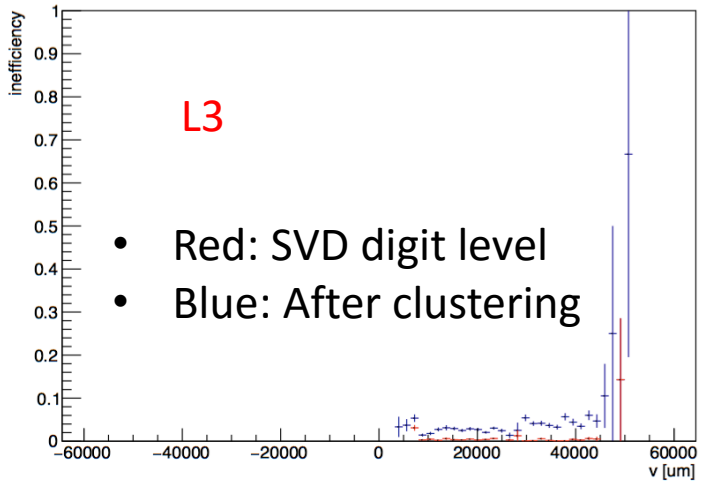
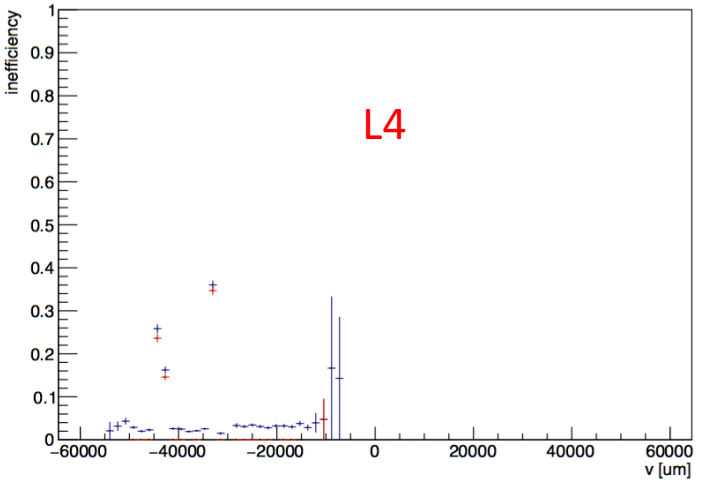
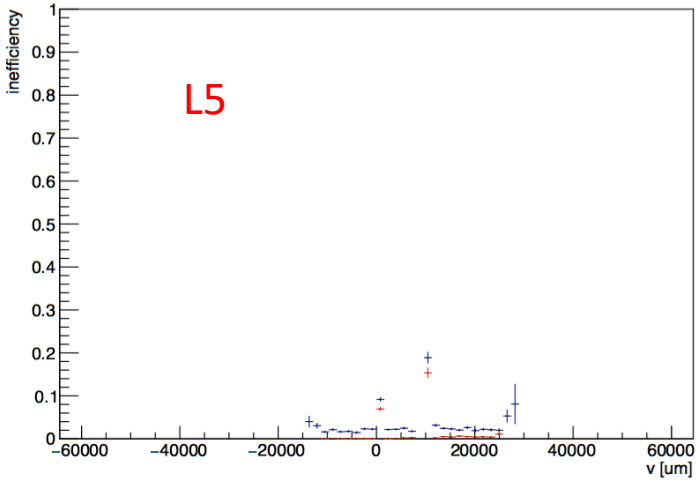
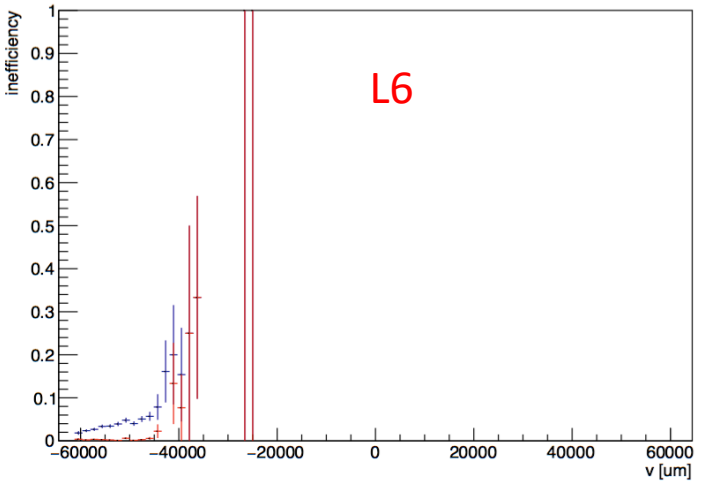
SVD Inefficiency (v-side)









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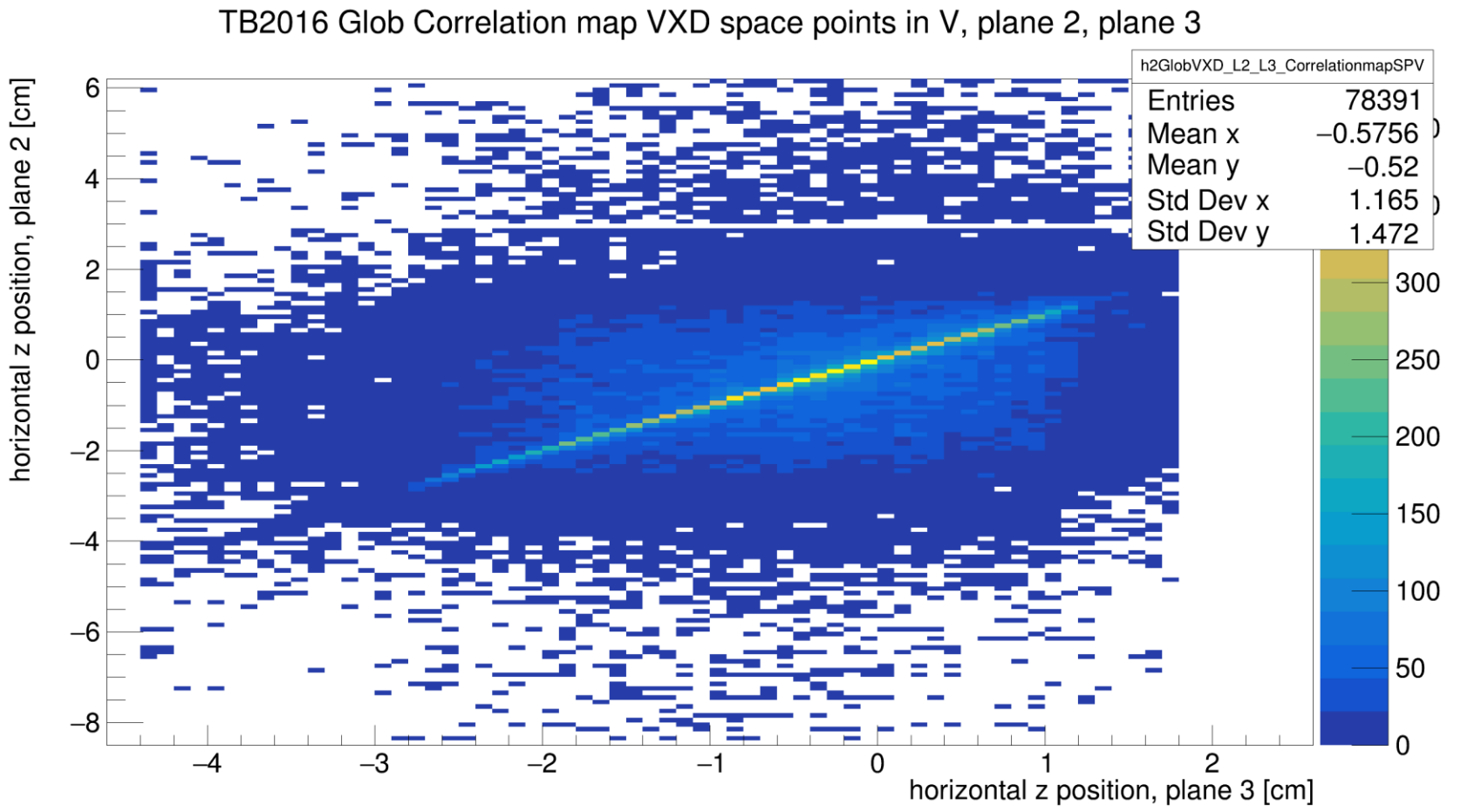
L2-L3 Correlations 0 T



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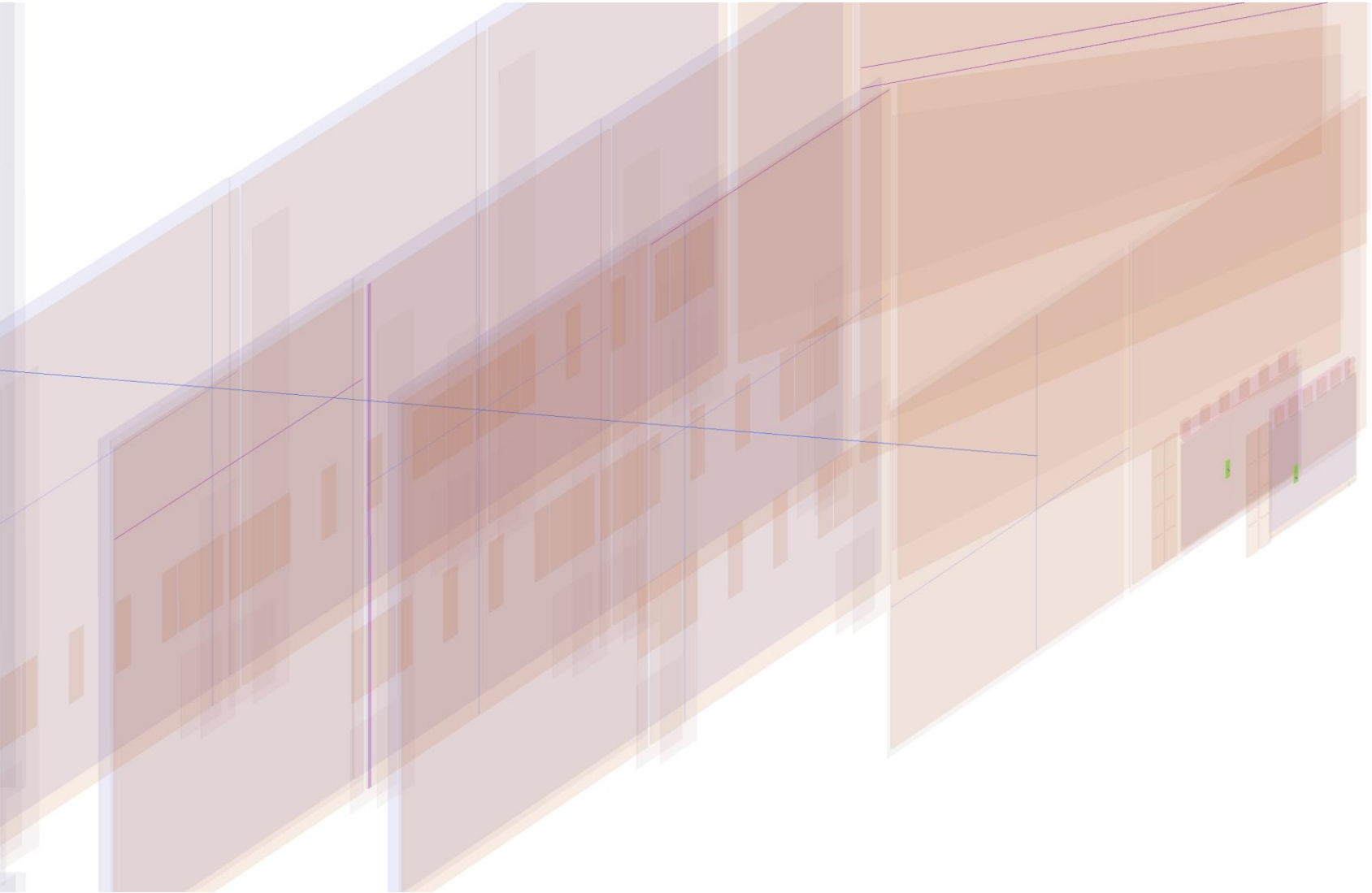
Online Data Reduction



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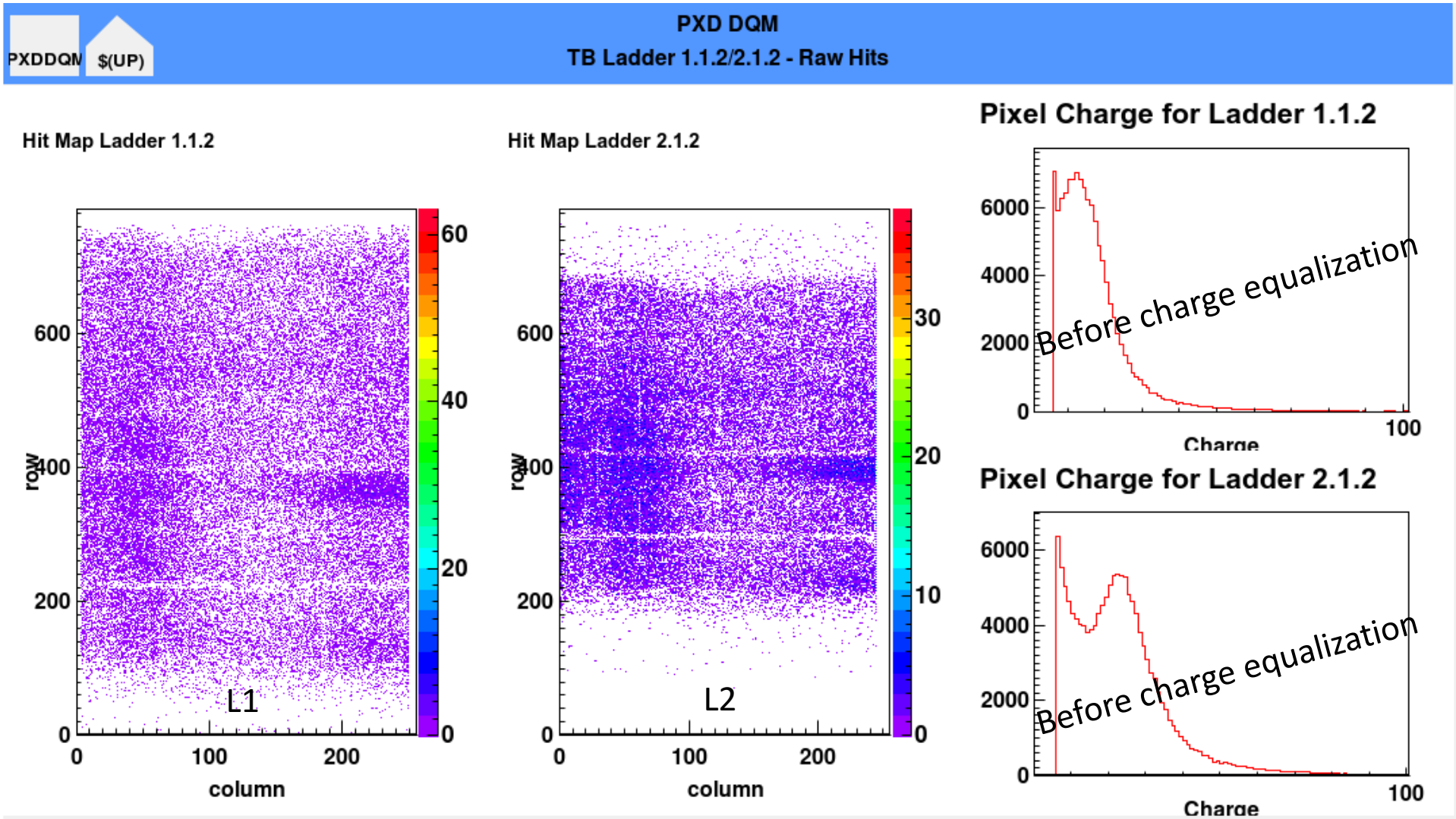
Express Reco: PXD DQM



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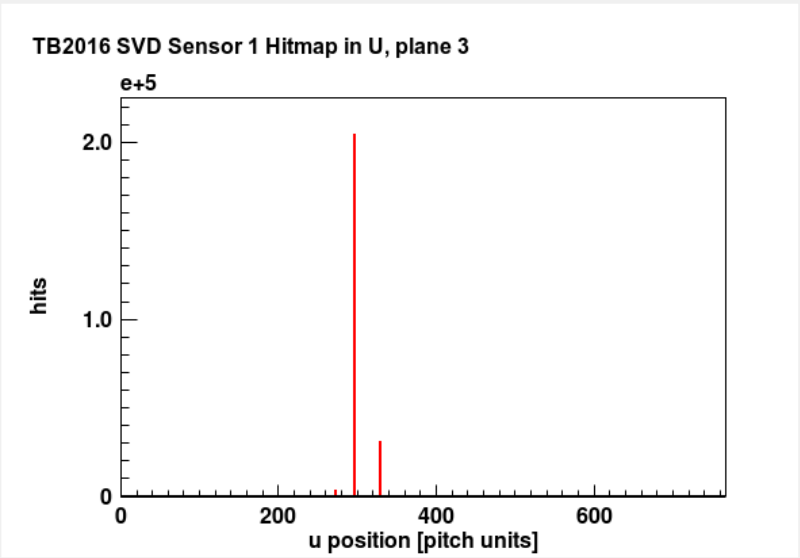
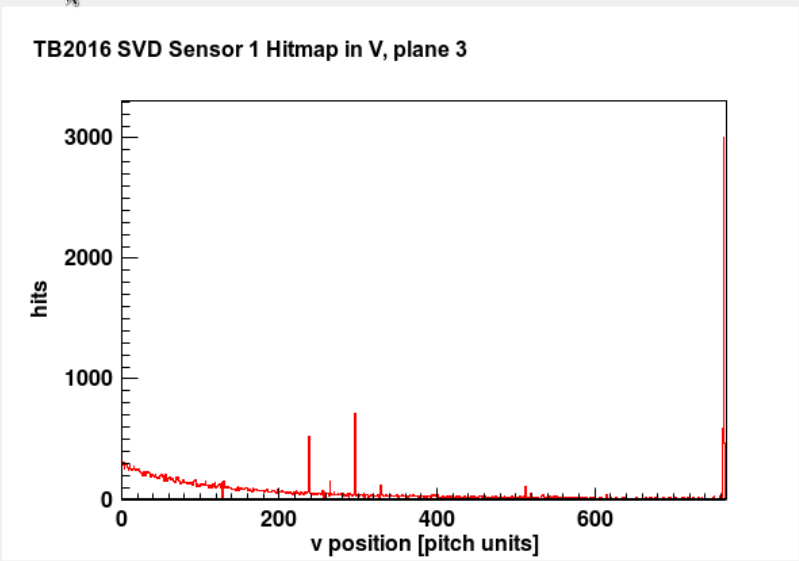
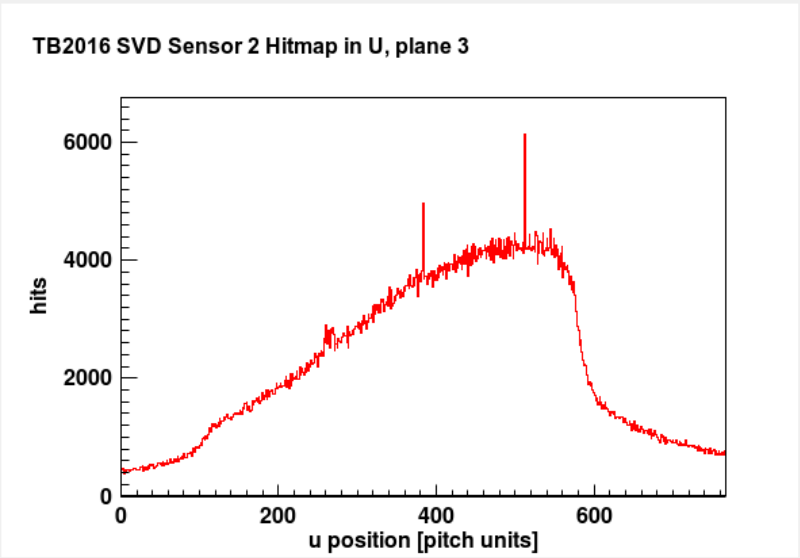
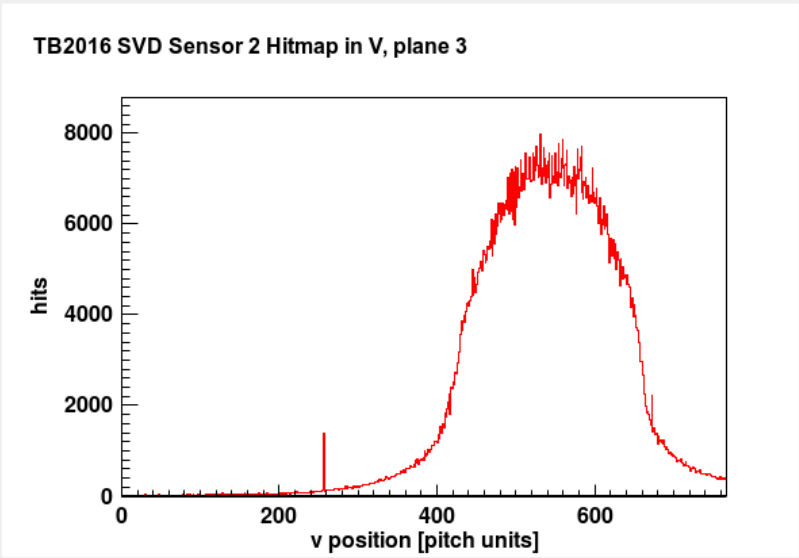
Express Reco: PXD DQM

DAQ CSS start | SVD DQM Main | Global hit map | Cluster charge L5 | Hit map L3 | DAQ Run control | SVDFTB:Config | DATA Flow









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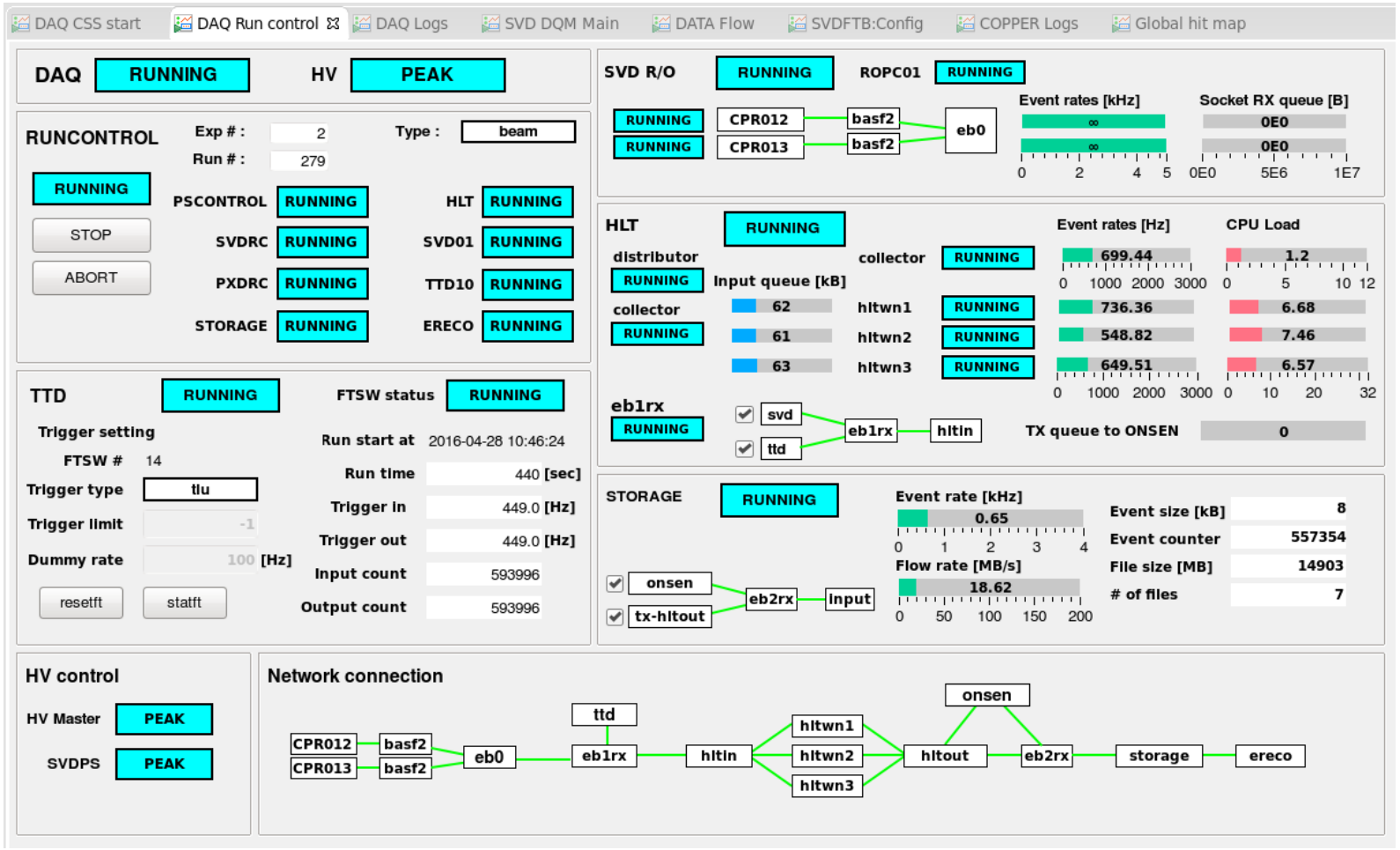
Global Run Control



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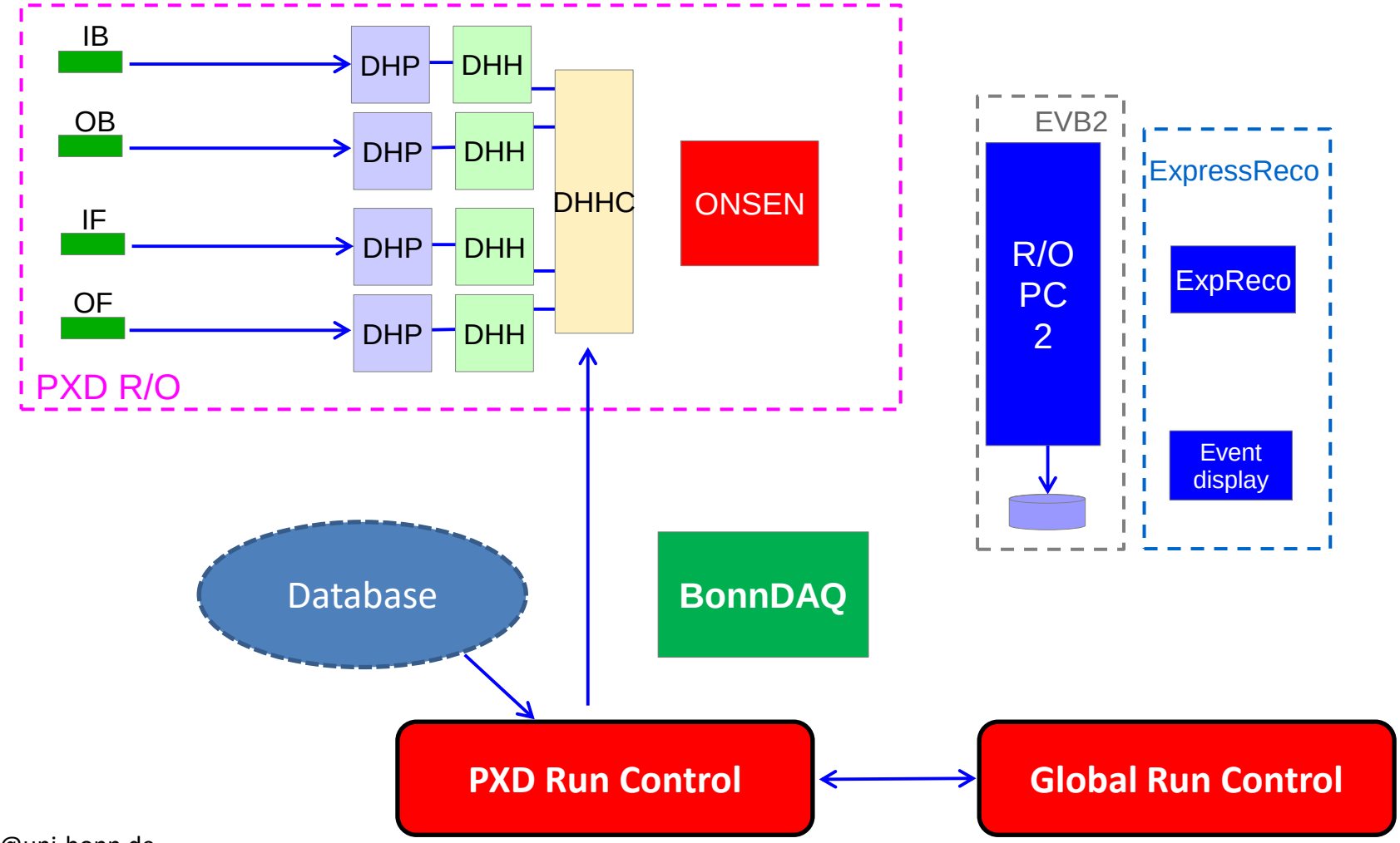
PXD Start Up



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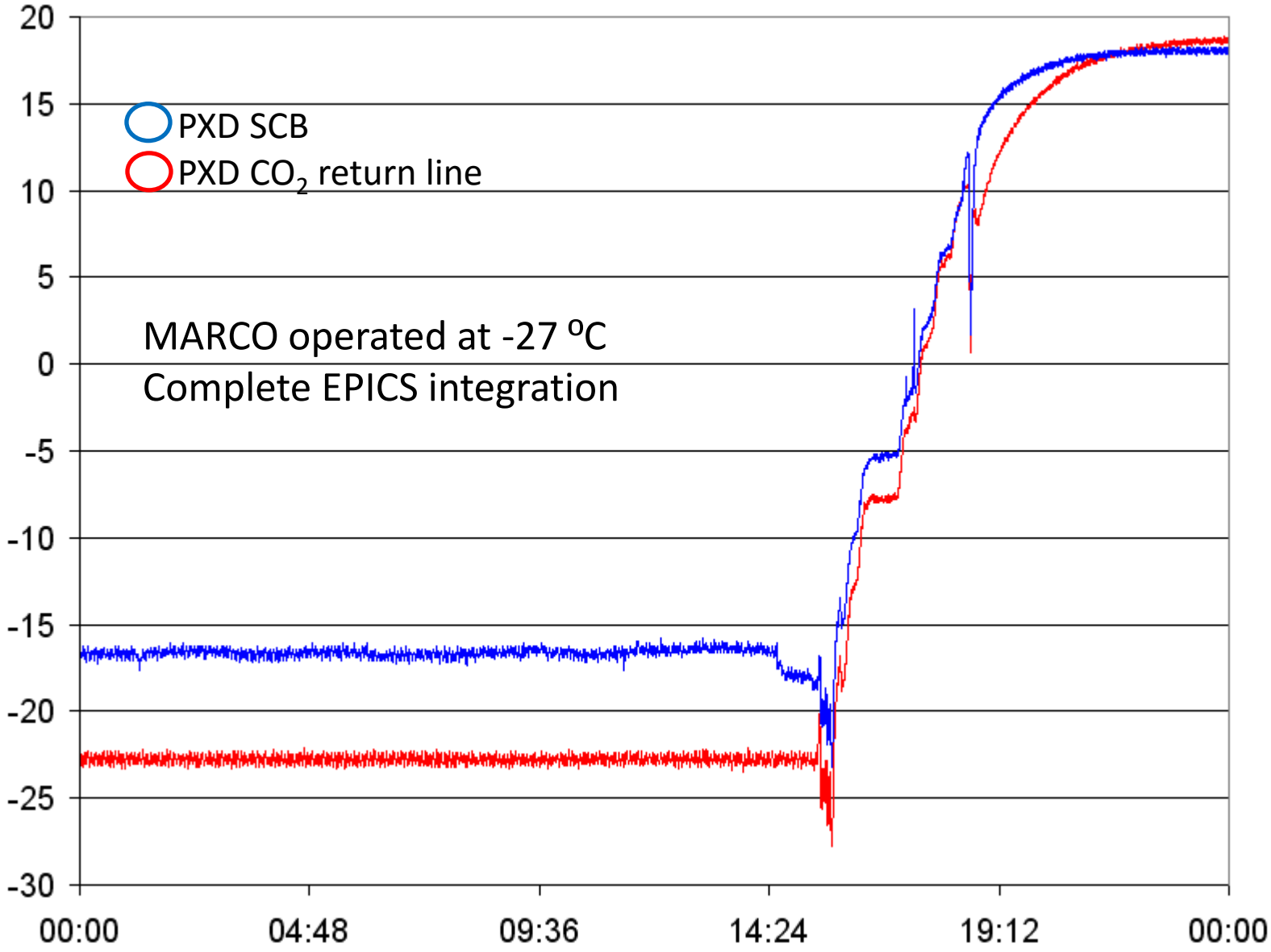
PXD Environmental Monitoring



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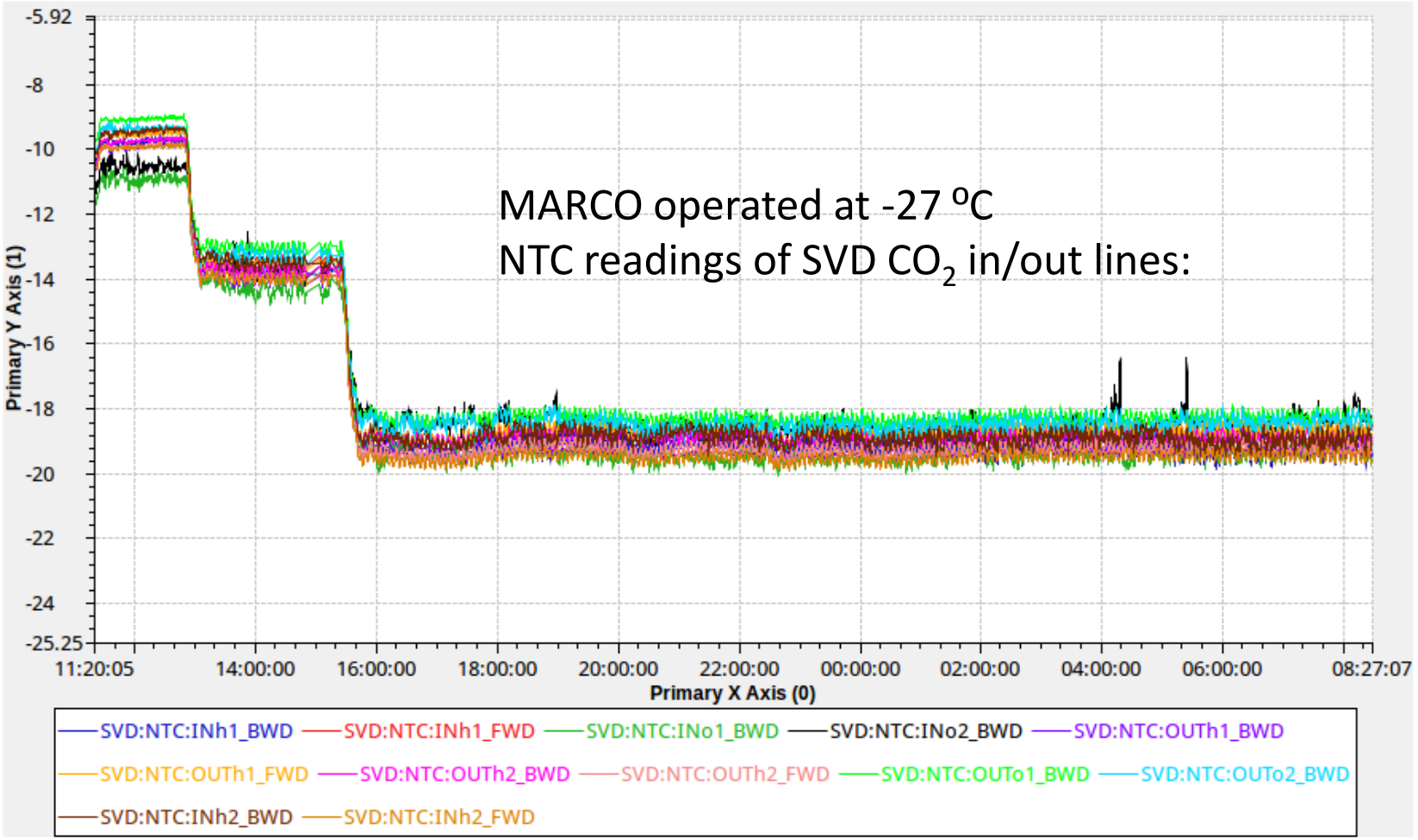
SVD Environmental Monitoring



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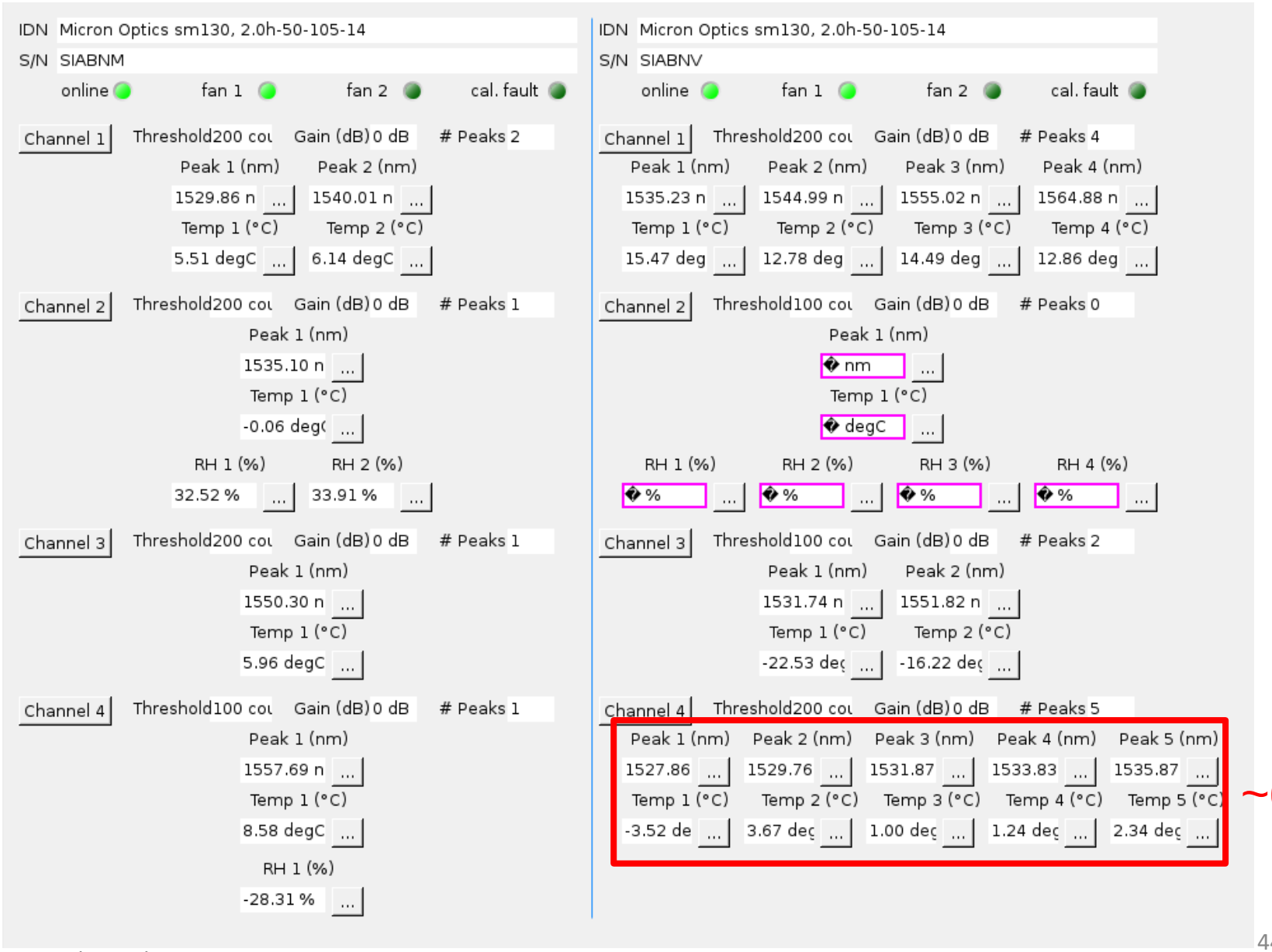
FOS Fiber in L6



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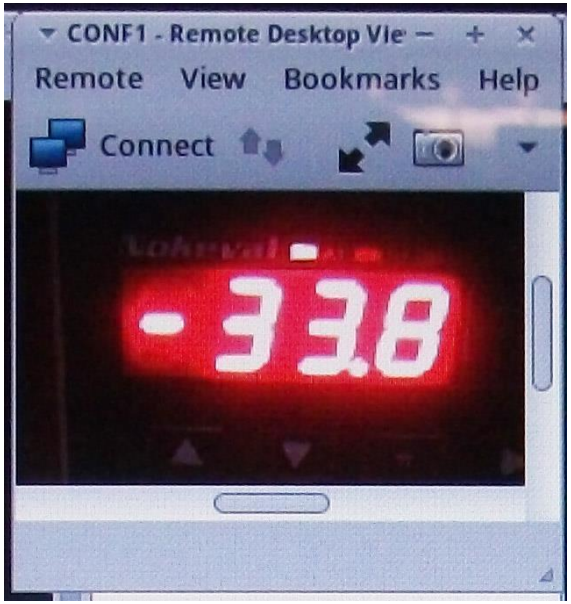
Dew Point: Sniffer



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Noise Immunity Studies

Probably the same noise as in TB Jan 2014. But this time the SVD system was immune due to measures taken in the grounding, hybrids, dock box and FADC.

* Systematic noise measurements
 - Spectrums and time diagrams of single and common mode noise in the SVD power and data cables, with PXD off and PXD on
 - Inductive probes in power cables, inductive probes in hybrid cables, current shunts in APV25 power lines

* Localization of the noise source
 - Sequential switch off all the components one-by-one (PXD, Magnet cooling, Scintillators, Telescope, Telescope chiller…
Noise bursts with 1.6 ms length all 10 ms with a modulation frequency of about 300 kHz in specific locations from the poorly filtered switched chiller power supply

Conclusions:
*** PXD does not seem to be the noise source**
*** SVD knows much better how to react**

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Main Results

- 2 PXD + 4 SVD layers fully operational: 'Final' Phase 2 hardware
- VXD: Hitmaps as expected in all 6 layers. SNR OK
- SVD efficiency found to be >90% (all layers and both sides)
- PXD residuals according to specs
- VXD correlations (mapping and timing)
- Online data reduction
- 7 kHz 'artificial' trigger rate for 1 hour
- Few hours 2 kHz steady data acquisition
- Alignment and BASF2 framework
- Noise immunity studies → No interference observed
- Run control: Start/Stop fully controlled by EPICS
- Environmental monitoring mostly integrated into EPICS
- Operation under realistic environmental conditions (CO_2 @ -27 ºC)

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Open Issues

- Different system gain for same settings. Rings.
- ASICs running at 250 MHz
- Links unstable.
- QC/QA power supplies and cables.
- Pedestal calculation and update. Pedestal distribution. 2b DAC.
- PXD internal trigger mismatch.
- Stable and traceable firmware versions. Additional features.
- DHP or matrix coordinate mapping (DHE-ONSEN).
- DATCON and SVD trigger mismatch.
- MARCO instabilities. Fixes for Phase 2.
- Regular system crashes of different kinds.
- ROI efficiency and purity.
- Jig and laser scans. Trigger.

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DHH related problems

☹ ☺

- No memory dump support for pedestal determination
- Limited DHE FPGA memory buffer, DDR buffer was not included in DHE yet

☹ ☺

- Event number mismatch at DHC event builder
- Unstable DHP links cause data errors and/or loss of link
- No recovery logic neither in DHE nor in DHC to handle wrong Data Format
- Other reasons ?

☹

- 65MHz DHP clock instead of 76 MHz => Asynchronous readout

☹ ☺

- Bonn DAQ error logs: timeout error between frames within one event(>5ms)
- DHH features multiple data buffers including DDR memory. DDR interface is optimized for bandwidth on expense of data latency

☹ ☺

- Unstable data taking (asserting FTSW busy) at 10kHz trigger rate
- DHE required 100us dead time! 7kHz worked fine.

Improvement of DHH functionality

- DHE: DDR memory for data buffering
  - Sharing detector data between overlapping events
  - No dead time
- DHE: DHP data consistency check and recovery logic
- DHC: DHE data consistency check and automatic resynchronization
- DHE: include clustering algorithm
- DHE: include programmable pixel remapping
- DHC: internal trigger generator for local runs

Data Flow (COPPER + HLT + Event Builder 2 + Storage) operation in DESY TB

Things that worked

- Stable operation with a full data flow both from SVD and PXD to storage.
- Parallel HLT processing with 24 cores with tracking and RoI generation confirmed.
- RoI feedback to ONSEN worked as expected.
- High rate processing was confirmed up to 8kHz (w/o tracking). Up to 2kHz in beam with tracking+RoI generation.

Things that didn't work

- Stability problem in the tracking software. VXDTF sometimes caused fatal errors resulting in the crash in HLT processing. The system was stable for overnight without tracking, though.
- "Event mixing" occurred although the event numbers were matched at event builder 2.
  * No event mis-match detected at DAQ level.
  * Problems existed in
    a) 1 event "internal" shift in SVD's FTB/FADC -> fix by SVD
    b) Event number mismatch observed between ONSEN and DHE/DHC in PXD readout
    -> Occured occasionally. Being studied by experts.

Things still to be tested

- Transport of error messages in HLT processing to slow control to notify shifters the real source of crashes clearly (HLT framework or tracking software)
- Need to establish the trouble recovery by shifters only without the help by DAQ experts.

Lessons learned

- HLT processing has to be robust for a long term running. Need to attract attention of software developers so that they can provide stable software which do not stop the processing even for problematic events.
  -> A self-recovery for problematic events in HLT/basf2 framework might be necessary, but is difficult to implement.....

- **Things that worked / Things that didn't work**
  - Back pressure handling for DHH/ONSEN was not probably working
  - Otherwise trigger timing distribution (TTD) worked as expected
- **Things still to be tested and how to address them / Lessons learnt**
  - UI didn't exist yet for various TTD settings
  - Better back-pressure/deadtime test/monitoring scheme is needed
  - Separate flags for DHH/ONSEN busy/error would be useful, need a b2tt revision
  - Latching the event number and attaching to data by SVD-FADC is probably not a good idea, it'd be better to count locally in FEE
  - True high rate test could not be made because of DHH limitation on minimum trigger interval ($\sim$100μs) [PXD responsibility]
  - FADC-controller deadtime generator didn't exist [SVD responsibility]
  - Above should be tested independently from the test beam
  - 15m CAT7 cable caused instability for some of the connections

Achievements and issues in Slow control

Things that worked:

- Run control including PXD / SVD RCs using CSS was established
- Configuration and monitoring of FTBs via HSLB and GUI worked well
- Monitoring of data flows and network connections helped to find DAQ stacks
- PXD / SVD DQMs were implemented and worked on CSS

Things that did not worked :

- Error notification (where and why) was still unclear for non-expert
  => Sanity checks of data quality (event mixing etc.) are not implemented yet
- DQM viewer still has some memory leaks
- PXD RC remained NOTREADY even if some devices lost connections
- PXD Power supply was invisible from DAQ-RC (SVD PS was visible but no DAQ control)

Things still to be tested:

- **Non-DAQ expert operation** for usual data taking
  => Clear error messages and indicators on GUIs
  => Firmware download for HSLB/FTSW/FTB via GUIs
  => Data checks in HLT (SVD) and storage (PXD) basf2 process
  => Reset procedure for DHE/DHC/ONSEN
- UIs for HLT (scripts and RoI sending) and TTD (register access) configurations
- Automatic data transfer without conflicts of slow control
- Power supply control (at least monitoring) by DAQ run control

* Event mismatches from different sources, reasons partly unclear
* Workarounds on HLT, unpacker and special modules
* Happened in significant amount of runs.
* TODO: Fix firmware, test!

Mapping, coordinate flipping
* Remapping not existing in DHH firmware -> consequences for ROI on HLT and PXD Unpacking
* Hotfix on ONSEN failed.
* Extend ROIs on HLT -- hampering ROI selection
* Remapping during unpacking + coordinate flips
* Remapping triggered other errors in software (PXD Sorter, clusterizer) -> problems in express reco, no DQM
* TODO: fix DHH firmware, remove patches from HLT and Unpacker as necessary

"Empty" first Ladder
* ordering of DHE data/DHE-ID was inverted (increasing order expected as for ROIs)
* Swapped cables
* In unpacker not checked -> fixed meanwhile
* TODO: first time two DHE were read out to ONSEN

Other things:
* Minor issues with data format from DHH (not as defined in specs) -> Trigger Errors and Warning in PXD Unpacker
* TODO: fix firmware, change Warning back to Errors in software

The objective before testbeam

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- Complete and functional data chain
  - Receive and extract data from FTB
  - Extract strip
  - Convert strip into coordinate
  - Tracking (Hough transformation)
  - Extrapolation
  - Correct transmission to ONSEN

- Extract information from Hough space not optimized
- Extrapolation not efficient
- Slow control not adapted

Bullet Points about the Cooling Operation in TB

- Things that worked.

In TB14, abrasive wear of gears caused clogging of micro filters. The new pump (upgraded in January) worked fine and solved this problem.

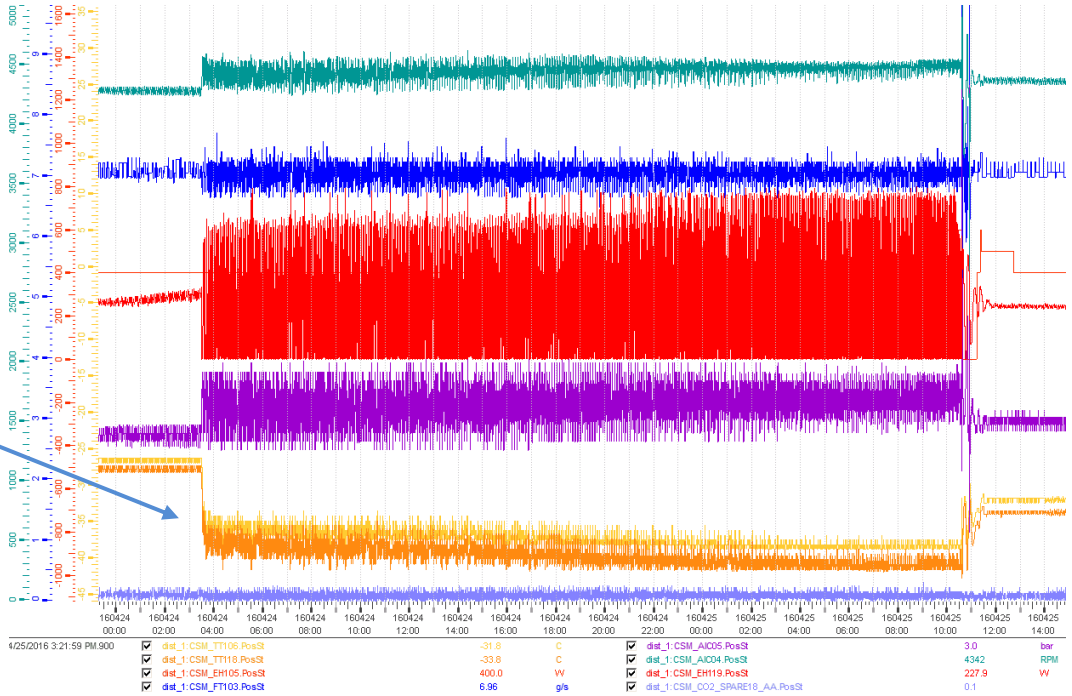
For long term running, we need to fill CO_2 while it's running, with the speed of 1kg/10min, no temperature changes in detector.

- Things that did not work.

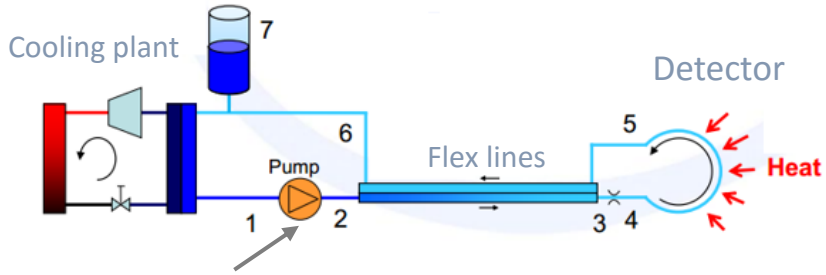
Leakage of CO_2!

→ low temperature below dew point (due to the logic setting in Marco)

Temperature on CO_2 in/outlet will decrease to -40°C.



→ May result in cavitation in the CO_2 pump, which can easily damage the pump in this case.



The sub-cooled CO_2 will prevent the pump from cavitation.

How to address.

Make sure the whole circuit is leak tight (Pressure test)
No level meter in Marco (not IBBelle), we need interlock on CO_2 temperature.

Things to be tested:

Do we really need so cold CO_2 of -30^{o}C? The full VXD thermal mock-up will tell us. **[Temperature dependency. Noise. C. M.]**

Lessons learnt.

Be careful in transportation.

What Worked & Lessons Learnt, Next Steps

- All IOCs ran without problems for the entire time. No interference in the SC networks.
- DATCON now speaks IPbus.
- Controlling several PS via PSC commands works fine.
- ONSEN reacts properly to RC.
- Starting with parameters from configuration database works.
- The EPICS archiver appliance is a good alternative to the SQL archiver.
- The requirements for the SC servers to be installed at KEK are now clear.

- Ahead: We do not need a beam test for much of the SC development. But we do need the hardware and some combined effort. Thorsten's departure complicates EPICS support in Munich.
  Proposal: Establish a regular (~monthly?) F2F hands-on meeting dedicated to SC integration.

What Didn't Work, Next Steps

- Reasons for many missed expectations:
  - „never change a running system“ attitude + still no stable system during the time allocated to SC development.
  - DHH and PS only connected to belle-iocpxd two days before the end of the testbeam.

- GUI integration
  - all experts at work ⇒ all expert screens.
  - (since: PS OPIs moved to new template + precompile)
- Run Control
  - small problem when the ONSEN init-program is run twice.
- Power Supply Control
  - No automatism in DHE controls beyond Python scripts. But sequence seems to be quite stable but for link problems.

Main Results

The overall campaign was a great success!

STILL not there yet

- Regular system crashes of different nature
- Trigger mismatches, 0-1 counting,…
- Further debugging still needed

Proposal:

- Permanent VXD set up at DESY with regular dry runs
- Step by step increasing complexity
- FANGS, CLAWS, PLUME dry integration CW46-CW48
- Final complete Phase 2 test beam in CW49-CW51

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Schedule 2016

DESY Testbeam Schedule 2016 - Version 8 - 27/04/2016

Ralf Diener, Norbert Meyners, Marcel Stanitzki - DESY Test Beam Coordinators

Week		TB21		TB22		TB24/1		TB24	
		DATURA	none	DURANTA	none	Telescope in PCMAG	PCMAG	none	
4-Jan-16	1	Shutdown							
11-Jan-16	2								
18-Jan-16	3								
25-Jan-16	4								
1-Feb-16	5								
8-Feb-16	6								
15-Feb-16	7								
22-Feb-16	8								
29-Feb-16	9								
7-Mar-16	10	Startup		Startup		Startup		Startup	
14-Mar-16	11	CMS-Pixel-Phase1		Mu3e					
21-Mar-16	12	Goettingen-CMOS		ATLAS-Pixel-AMSH35					
28-Mar-16	13	ATLAS-Pixel-MPP							
4-Apr-16	14	CMS-Pixel-Phase1				Belle-II			
11-Apr-16	15	PLUME							
18-Apr-16	16	PLUME							
25-Apr-16	17	CMS-Pixel-Phase1							
2-May-16	18				CALICE-AHCAL			SiPM	
9-May-16	19	ATLAS-DMicromegas			CALICE-AHCAL			SiPM	
16-May-16	20								
23-May-16	21	ATLAS-Strip-Glue		ATLAS-ITK-Strip					
30-May-16	22	ATLAS-Strip-Glue		ATLAS-ITK-Strip					
6-Jun-16	23	CMS-Phase2-EPI						CMS-Pixel-Phase1	
13-Jun-16	24	CMS-Phase2-EPI							
20-Jun-16	25				CALICE-AHCAL				
27-Jun-16	26								
4-Jul-16	27	CMS-Pixel-PII-KA							
11-Jul-16	28	CMS-Pixel-PII-KA							
18-Jul-16	29								
25-Jul-16	30			ATLAS-Strip-Glue					
1-Aug-16	31	Summer Students		ATLAS-Strip-Glue					
8-Aug-16	32								
15-Aug-16	33								
22-Aug-16	34	FCAL							
29-Aug-16	35							CBM-TRD	
5-Sep-16	36							CBM-TRD	
12-Sep-16	37								
19-Sep-16	38								
26-Sep-16	39								
3-Oct-16	40								
10-Oct-16	41							PANDA-DIRC	
17-Oct-16	42	CMS-Phase2-EPI						PANDA-DIRC	
24-Oct-16	43	CMS-Phase2-EPI		HEP for Teachers				PANDA-DIRC	
31-Oct-16	44								
7-Nov-16	45			Mu3e					
14-Nov-16	46								
21-Nov-16	47					ATLAS-ITK-Strip			
28-Nov-16	48					ATLAS-ITK-Strip			
5-Dec-16	49					Belle-II			
12-Dec-16	50								
19-Dec-16	51	Beam till 23/12 0800							
26-Dec-16	52	Shutdown							

Announced

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PXD Standalone TB Campaign

- What do we want to measure?
  - Charge collection properties
  - Efficiency in long matrices
  - Lorentz angle

- What do we need?
  - PCMAG and telescope
  - FE-I4 trigger
  - Rotating stages
  - Modified jig
  - Stable firmware for UDP to BonnDAQ and mem_dump
  - Power supply and long cables

- After the test beam, start putting together all the pieces for the **dry tests**

- 18th May, tentative date for opening the dry box (SVD to confirm)

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DESY Testbeam Schedule 2016 - Version 8 - 27/04/2016

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11-Jan-16	2								
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25-Jan-16	4								
1-Feb-16	5								
8-Feb-16	6								
15-Feb-16	7								
22-Feb-16	8								
29-Feb-16	9								
7-Mar-16	10	Startup		Startup		Startup		Startup	
14-Mar-16	11	CMS-Pixel-Phase1		Mu3e					
21-Mar-16	12	Goettingen-CMOS		ATLAS-Pixel-AMSH35					
28-Mar-16	13	ATLAS-Pixel-MPP							
4-Apr-16	14	CMS-Pixel-Phase1				Belle-II			
11-Apr-16	15	PLUME							
18-Apr-16	16	PLUME							
25-Apr-16	17	CMS-Pixel-Phase1							
2-May-16	18				CALICE-AHCAL			SiPM	
9-May-16	19	ATLAS-DMicromegas			CALICE-AHCAL			SiPM	
16-May-16	20								
23-May-16	21	ATLAS-Strip-Glue		ATLAS-ITK-Strip					
30-May-16	22	ATLAS-Strip-Glue		ATLAS-ITK-Strip					
6-Jun-16	23	CMS-Phase2-EPI						CMS-Pixel-Phase1	
13-Jun-16	24	CMS-Phase2-EPI							
20-Jun-16	25				CALICE-AHCAL				
27-Jun-16	26								
4-Jul-16	27	CMS-Pixel-PII-KA							
11-Jul-16	28	CMS-Pixel-PII-KA							
18-Jul-16	29					PXD			
25-Jul-16	30			ATLAS-Strip-Glue					
1-Aug-16	31	Summer Students		ATLAS-Strip-Glue					
8-Aug-16	32								
15-Aug-16	33								
22-Aug-16	34	FCAL				Irradiation			
29-Aug-16	35							CBM-TRD	
5-Sep-16	36					VXD Dry Tests			
12-Sep-16	37								
19-Sep-16	38								
26-Sep-16	39								
3-Oct-16	40								
10-Oct-16	41								
17-Oct-16	42	CMS-Phase2-EPI							
24-Oct-16	43	CMS-Phase2-EPI		HEP for Teachers					
31-Oct-16	44								
7-Nov-16	45			Mu3e					
14-Nov-16	46					Phase 2 Dry Integration			
21-Nov-16	47								
28-Nov-16	48								
5-Dec-16	49								
12-Dec-16	50					Belle-II			
19-Dec-16	51	Beam till 23/12 0800							
26-Dec-16	52	Shutdown							

Announced

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Thanks

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